ADULT LEARNING

THORNDIKE

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Studies in Adult Education

ADULT LEARNING

STUDIES IN ADULT EDUCATION

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ADULT LEARNING

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PREFACE

This volume presents the results of two years of research done with the aid of a grant from the Carnegie Corporation, together with such a general treatment of the topic as seemed desirable. Much of the evidence for our conclusions, especially that of a technical nature, has been segregated in a series of appendices. The general text will, we trust, be intelligible and useful to all those who are concerned with the teaching of adults. The author named first is responsible for the general plan of the work and for the presentation of it in this volume. The detailed planning and execution of the experiments are to be credited largely to Dr. Bregman, Dr. Tilton, and Dr. Woodyard. Dr. Bregman and Dr. Tilton had practically entire responsibility for the work with adult evening school pupils and prisoners respectively; Dr. Woodyard, assisted by Parrish Little, secured the data from secretarial schools and coöperated in nearly all of the work. Dr. Bregman, assisted by Mrs. G. J. Ruger, directed part of the work with adults of superior intellect. We are glad to acknowledge also the aid of Mr. A. Grove Day and Miss Mabel Wilcox, members of the staff of the Institute, and the valuable coöperation of the Superintendent of Schools of New York City, the Director of its evening schools, the Principal of the New York Evening High School, the Educational Director of the New York State Prison at Ossining, the International Auxiliary Language Association, and the authorities of the Conklin, Katherine Gibbs, Packard, Miller, and United States Secretarial Schools.

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E. L. Thorndike.

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CHAPTER I

Introduction

It is the purpose of this book to report the facts concerning changes in the amount and changes in the nature of ability to learn from about age fifteen to about age forty-five, and especially from age twenty-five to age forty-five. This information should be useful in the guidance of adult education in all its multifarious forms. Public evening schools, educational departments of the Young Men's Christian Association, other philanthropic agencies for the welfare of adults, and correspondence schools, which are the most conspicuous forms of systematic education of adults, need a better scientific basis both for selecting students and for training them. The training of workers to use new machines and new methods, the training of recruits in times of war, and the self-education of individuals are the product of custom and intuition rather than of ascertained facts. The most successful of the teachers and supervisory officers in these fields would be almost unanimous in acknowledging the lack of any surety concerning the changes, either quantitative or qualitative, which age brings in the ability to learn. They have had to trust to their intuitions and practical experience with the adults whom they have taught.

Such practical experience develops in the gifted an insight into concrete particular educational situations and skill and readiness in meeting them, but it does not as a

rule produce general truths about learning or of teaching. The insight and skill are not transmissible to all by rule and precept, but have to be acquired slowly and expensively, at the best by imitation and at the worst by a repetition of the experience itself in each teacher. There have been many instances of very great success by many individual teachers and directors in many varieties of education with many adult classes. But they have not produced a general theory or technique. A compilation of records of teaching experience with adult classes, including both notable successes and notable failures, would be of very great value. It would stimulate thought and action and provide for the beginner a partial substitute for direct experience and imitation. An analysis of it would help to settle certain disagreements amongst those engaged in adult education, and might bring striking and useful facts to light.

But even if all the experiences of all the teachers of adults were fully and accurately reported, they would probably still not provide a general theory and technique. These experiences are too complicated and confused by a multiplicity of varying factors. Old learners, for example, may be the specially ambitious old who make sacrifices to learn more, or the dull old who did not learn when they were young because they were dull, or the foreign old or the gullible old who are enticed by seductive advertisements.

Even the far simpler problems of learning by the young in the fairly standardized situations of the regular elementary-school and high-school subjects require more than experience to provide clear answers. Even with them, definite experiments, with the number of variables reduced (to one, if possible) and with expert protection against sources of error, have been found necessary in order to secure facts of demonstrable truth and general import.

Psychology and general educational science have provided no satisfactory answers to our questions. There has been in the main a neglect of the problem, or an acceptance of the proverbial conventional opinion that it is especially important to train up the *child* in the way he should go, and that it is hard to teach an old dog new tricks. The best known statement is by James, who wrote, in a discussion of the waning of curiosity: "Outside of their own business, the ideas gained by men before they are twenty-five are practically the only ideas they shall have in their lives. They *cannot* get anything new. Disinterested curiosity is past, the mental grooves and channels set, the power of assimilation gone. Whatever individual exceptions might be cited to these are of the sort that 'prove the rule.'" ('93, vol. II, p. 402.)[1]

The latest authoritative statement is that of Hollingworth ('27, p. 310 f.) who writes: "Very few experimental data or measures are available on the mental changes after the period of early maturity [by which is meant the years from eighteen on]. . . . In general the fact seems to be that with increasing age, after maturity, learning capacity declines while general alertness and ability to utilize factors already acquired are still at their maximum. . . . Even if these tentative results point to the actual limitations of the establishment of new associations in age, they do not yet prove that learning capacity ever completely ceases in the average case. The exact determination of the rate of mental changes in age is a matter for future research."

There has never been an extensive and systematic inquiry seeking to discover whether and to what extent infancy, childhood, and adolescence do have by nature an advantage over the years from twenty to forty in respect of ability to learn.

[1] The years, volumes, and pages cited in this text in parentheses refer the reader to the Bibliography of References Made in the Text, page 319.

We have made such an inquiry so far as time and means were available and present the results in the next ten chapters. In Chapter XII, we deal very imperfectly with the still more difficult question of qualitative differences in learning.

CHAPTER II

Facts of Adult Learning Reported in the General Literature of Psychology and Education

Although psychology offers no accepted general account of the relation of age to ability to learn, there are many facts concerning learning by adults scattered through the records of experiments on learning. Indeed most of the early investigations of learning concern the learning of persons twenty to thirty years old or older. The subjects of these experiments were often graduate students and instructors.

The following summaries or samples demonstrate that the adults in question made large amounts of improvement and made them at rapid rates in all sorts of mental operations — in simple sensorimotor abilities, in observing details, in simple association or habit formation, in learning elaborate systems of motor and mental habits, in memorizing (save when that ability has been already brought to a rather high status), and in other still more complex functions which have been tested.

Improvement in Simple Sensorimotor Abilities

Partridge ('00) measured the amount of practice required by two adults, in learning not to wink when a hammer of rubber struck a plate of glass in front of the eye. The course of learning not to wink at the sight and sound of the hammer was as follows, each number giving

the number of times that the wink was inhibited in each successive hundred trials:

Subject A: 0, 0, 11, 6, 16, 20, 34, 53, 36, 42, 57, 45, 42, 53, and 50.
Subject B: 0, 0, 2, 4, 4, 0, 8, 2, 6, 4, 0, 28, 8, 4, 21, 32, 65, 39 81, 83, 77, 92, 86, 97, 99, 88, 98.

Bair ('02, p. 30) tested four subjects' gain in tossing shot into a glass, sixty tosses being made a day for twenty days. The score being the number of successes out of sixty, the four adult males improved from 32, 23, 17, and 15 to 56, 37, 43, and 42.

Whitley ('11, pp. 112 and 130 f.) found that twenty practices in drawing a line between the two parallel lines of a maze, one being taken daily except Sundays, reduced the score from 194 to 123 for the average of nine individuals. The score is the time plus one tenth for 1 or 2 touches, two tenths for 3 or 4 touches, three tenths for 5 or 6 touches, and so on.

Swift ('03) had five adult men practice at "keeping two balls going (in the air) with one hand, receiving and throwing one while the other is in the air. . . . The balls used were of solid rubber and weighed 122.6 and 130.2 grams. . . . Their diameters were 42 and 44 mm., respectively. . . . The daily program consisted of ten trials, the subject in each case [i.e., trial] continuing the throwing until he failed to catch one or both of the balls." ('03, p. 210 f.) "The number of catches made in each trial was immediately recorded," the sum of these ten numbers forming the score for the day. "After each trial the subject rested as long as seemed necessary." [ibid.] At the start these men could make only from 1 to 10 tosses before failing, but after about an hour spent in tossing they could make 30 or more. Four of them attained (in from 2 to 5 hours of practice) a skill such that they could average over a hundred tosses before failing;

and the fifth man doubtless would have done so, except that he practiced for only a short time.[1]

Wells ('08-*b*) found with two adult subjects that thirty days of practice at tapping a telegraph key at maximal speed for thirty seconds, ten times a day, five with each hand, separated by nine rests, each of one hundred and fifty seconds, produced an improvement from an initial score of about 186 taps in thirty seconds to a final score of 215 taps in thirty seconds, averaging the two subjects' records for right hand and left hand.

Improvement in Observing and Reacting to Simple Details

Wells ('12) found, with ten adult subjects (hospital nurses), in cancelling a hundred zeros in a page specially constructed of a thousand mixed digits, that one hundred and ten such tests, one a day for ten days and five a day for twenty days (Sundays being omitted), involving on the average about 140 minutes of practice, raised the number of zeros cancelled per minute from an average of about 45 to one of about 100, without (if we understand Dr. Wells' report) diminishing precision.

Forming Simple Habits

Bair ('02, 15 ff.) studied the improvement in a very simple form of typewriting, only six keys being used and only six corresponding colors or letters arranged in a fixed "sentence" or sequence of fifty-five colors or letters. The time taken to write this series without error was taken after seven repetitions of it at fixed rates in time with a metronome; then after another set of seven such;

[1] Joseph Peterson ('17) has repeated Swift's ball tossing experiments with twenty-five undergraduate college students. He does not give ages and his method makes any exact comparison of these younger persons' gains with those reported by Swift impossible. Our general impression is that there is no great difference.

and so on until (including the series at the learner's minimum time for errorless writing) one hundred and twenty-eight repetitions were made. The average time for four subjects was 61 seconds for the eighth, and 37½ seconds for the hundred and twenty-eighth repetition.

In another similar experiment three different individuals repeated the same series at maximum errorless rate five times a day for seven successive days. The average times required for the first and thirty-fifth repetitions were, respectively, 74 and 40 seconds. The individuals scored 62, 79, and 82 in the first trial and 40, 38, and 42 in the thirty-fifth. In a third similar experiment, but with seven keys and with letters instead of colors, the series of fifty-five was written three times daily for nine days, twice with the metronome at one stroke per second, and once as rapidly as possible without errors. The number of errors at the specified rate dropped from 35 to 0; the time at maximum errorless rate dropped from 79 at the end of the first day to 47 at the end of the ninth.

Bair also studied the simultaneous formation of four habits requiring the attachment of different bonds to the same general situation according to differences in the mental set. "Each day's experiment was as follows: First, the alphabet was repeated as rapidly as possible forward; secondly, the letter *n* was intercepted between each (pair) of the letters; thirdly, the alphabet was repeated as rapidly as possible backward; and lastly, the alphabet was repeated backward, intercepting *n* between each (pair) of the letters." (Bair, '02, p. 28.) On the whole, an initial time of 123.9 seconds fell to 24 seconds. Even by the fifth time it had fallen to 45.6 seconds.

Thorndike ('10) studied the improvement of nineteen university students from 22 to 35 years old, in adding daily, for seven days, 48 columns each of 10 one-place numbers (no *0's* or *1's* being included). Seven printed blanks of equal difficulty were used. The forty-eight

sums were written. The improvement was as shown in Table 1, below. An addition of half the time required for one example was made for each wrong sum. The time of writing the sum of a column of ten numbers was treated as equivalent to the time of one addition. The "time spent in practice" as recorded in this table is not the total time, but the time from the point for which initial efficiency was measured (that is, a point at the middle of the first day's practice period) to the point for which final efficiency was measured (that is, a point at the middle of the last day's practice period).

TABLE 1

IMPROVEMENT IN ADDITION: ADULTS

Amount of improvement in relation to length of practice and initial ability (after Thorndike ['10])

INDIVIDUAL	LENGTH OF PRACTICE IN MINUTES	ADDITIONS IN FIVE MINUTES		GROSS GAIN
		First day	Seventh day	
K	32	313	600	287
H	35	301	456	155
M	38	235	400	165
D	38	253	441½	188½
B	39½	228	398	170
I	44	336	294½	−41½ (loss)
A	44½	254	362	108
L	48	238	356	118
O	49	326½	470	143½
G	50	240	316	76
C	51	247	301	54
R	57	204	297½	93½
J	59	218	303	85
N	63	178	271½	93½
S	64½	163	271½	108½
P	69½	145	247	102
F	71	175	178	3
Q	71½	165	228½	63½
E	74	137	235½	98½

Wells ('12) found, with ten adult subjects (hospital nurses), in oral addition of one-place numbers, printed vertically one close above the other and in convenient

columns, that 150 minutes, distributed over five weeks, six days a week, raised the amount done to nearly double without (if we understand him) decreasing the precision. A rough computation from Wells' curves gives the average ratio of the work of the thirtieth to that of the first day as 1.96, the individual scores being, as estimated from the curves, those shown in Table 2, below.

TABLE 2

IMPROVEMENT IN ADDITION: ADULTS

Amount of improvement in relation to length of practice and initial ability (after Wells ['12])

INDIVIDUAL AND SEX	NUMBER OF ADDITIONS IN FIVE MINUTES			PERCENTAGE WHICH AMOUNT DONE ON 30TH DAY WAS OF AMOUNT DONE ON FIRST DAY
	First day	Thirtieth day	Gross gain	
1 *f*	150	280	130	187
2 *m*	180	380	200	211
3 *m*	200	430	230	215
4 *f*	220	380	160	173
5 *m*	225	368	143	164
6 *m*	225	460	235	204
7 *f*	235	570	335	243
8 *f*	250	440	190	176
9 *f*	260	540	280	208
10 *m*	290	540	250	186

Pyle ('13) had adult subjects transcribe a book into 26 characters, "simple and easily made," one for each letter of the alphabet, for half an hour daily for fifteen days. The number of words transcribed nearly quadruples from the first to the fifteenth period.

Dearborn and Brewer ('18) conducted experiments in learning to translate prose into a secret code in the case of college and graduate students. The practice consisted of twenty-one periods, each of 5 minutes. Every individual made substantial gains. On the average the thirty-five men rose from 43 to 239 units done in 5 minutes.

Learning More Elaborate Systems of Habits

Swift ('04) practiced typewriting by the sight method for an hour a day for fifty days, at the age of forty-three, making in the last five days scores averaging about 1060 words per hour, or 17½ per minute.

Book ('08) had two adults, X and Z, practice at typewriting by the sight method 30 minutes a day for 174 and 86 days respectively. X rose from 30 strokes per minute to 90 in about 15 hours, and then improved more slowly to about 160 strokes per minute. Z rose from about 45 strokes per minute to 110 in about 15 hours, and then more slowly to about 150 strokes at the end of the 43 hours. Book also had another adult (Y-1) practice an hour a day for 130 days, using the touch method. At the end of 15 hours he had not quite reached 90 strokes per minute. He reached 210 in about 100 hours. In these experiments, "Each letter and mark of punctuation, not requiring a shift of the carriage, was counted as one stroke; striking the word-spacer was counted as half a stroke; making a capital or any mark requiring the use of the 'shift key' was counted as two strokes; moving the carriage back to make a line was counted as three strokes." ('08, p. 18)

Hill and Rejall ('13) practiced typewriting by the sight method, using a page of approximately 300 words as the unit task. At the first writing, they required 43 minutes 50 seconds and 42 minutes to complete the page, writing at the rate of 6.8 and 7.1 words per minute, with 34 and 57 errors. This improvement was as follows:

After	10.0	hours of	practice	R	wrote	16.3	words	per	minute:	36	errors
"	10.3	"	"	H	"	13.3	"	"	"	13	"
"	20.9	"	"	R	"	19.4	"	"	"	11	"
"	19.6	"	"	H	"	17.5	"	"	"	11	"
"	30.5	"	"	R	"	25.2	"	"	"	10⅔	"
"	29.7	"	"	H	"	20.9	"	"	"	8⅓	"

At the age of forty-two, Swift ('03) studied shorthand sixty-eight days for an hour and a half a day, writing James' Talks to Teachers from dictation and reading his own copy written ten days or more before. The

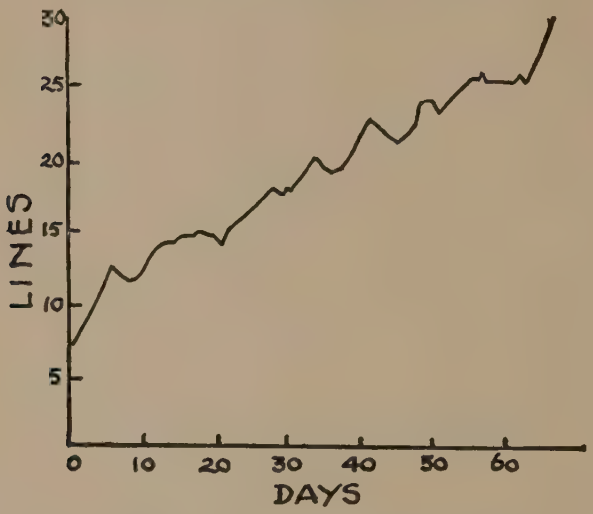


Fig. 1. Swift's Improvement in Writing Shorthand

improvement in writing was as shown in Fig. 1, each point on the graph representing the average of three successive days.

Pyle ('14) measured the improvement of two groups of adults (summer-session students at the University of Missouri) in typewriting. One group of five practiced ten half-hour periods a day with half-hour rests between for nine days, (successive except for an omitted Sunday), making 45 hours in all. Another group of five practiced for two half-hour periods a day at 8 or 9 A.M. and at 2 or 3 P.M., for forty-five days (successive except for the omission of Sundays and an occasional Saturday). The first group averaged 99 words in the first half-hour period and 600,

633, 631, 590, and 606 in the last five periods. The second group averaged 142 in the first half hour and 689, 739, 737, 709, and 753 in the last five periods. The number of errors per hundred words dropped in the first group and rose in the second. For both together it remained almost constant, at about five. The details appear in Table 3.

TABLE 3

The average number of words typed by adults in each half hour. After Pyle ('14, Table 1)

HALF HOUR	5 SUBJECTS 5 HRS. DAILY	5 SUBJECTS 1 HR. DAILY	HALF HOUR	5 SUBJECTS 5 HRS. DAILY	5 SUBJECTS 1 HR. DAILY	HALF HOUR	5 SUBJECTS 5 HRS. DAILY	5 SUBJECTS 1 HR. DAILY
1	99	142	31	392	487	61	524	646
2	204	228	32	381	496	62	528	639
3	223	252	33	390	505	63	546	644
4	238	273	34	393	518	64	537	641
5	259	280	35	397	524	65	533	645
6	249	307	36	405	595	66	521	624
7	250	308	37	382	557	67	491	653
8	252	338	38	388	564	68	492	653
9	263	352	39	360	554	69	494	600
10	287	370	40	351	557	70	482	643
11	324	404	41	418	502	71	511	546
12	308	392	42	425	545	72	546	606
13	316	385	43	448	578	73	551	696
14	295	391	44	457	566	74	585	688
15	307	411	45	479	599	75	548	666
16	335	413	46	442	572	76	538	710
17	324	450	47	453	623	77	544	685
18	337	403	48	470	596	78	570	730
19	336	435	49	479	617	79	564	733
20	333	459	50	472	621	80	558	680
21	377	468	51	458	593	81	552	726
22	328	451	52	499	585	82	576	730
23	365	488	53	474	586	83	576	754
24	380	431	54	506	614	84	583	721
25	377	502	55	533	617	85	615	735
26	375	448	56	507	616	86	600	689
27	350	487	57	445	550	87	633	739
28	376	472	58	544	617	88	631	737
29	394	478	59	534	617	89	590	709
30	394	492	60	455	616	90	606	753

Memory

Ebert and Meumann ('05) found with six adult subjects that the last four of twenty-four series, each of twelve nonsense syllables, two of which were learned per day, required on the average 12½ repetitions, instead of the 16¼ repetitions required per twelve-syllable series in the first four. Besides the intervening practice in learning the series, each was also relearned, so that the drop from 16¼ to 12½ is attributable to the learning of twenty series, plus about half as much time spent in relearning.

The improvement in relearning after twenty-four hours was from an initial average of 6⅓ repetitions to an average of 5½.

After learning and relearning eight more twelve-syllable series and a considerable amount of miscellaneous memory drill, an average of 9⅙ repetitions was required in the next four series for the learning (per twelve-syllable series); and 4½ for the relearning.

After a total of forty-four series, each of twelve nonsense syllables, had been learned and relearned, plus the miscellaneous drill above mentioned, the next four series showed an average requirement of 7.8 repetitions for learning a series; and 3.1 repetitions for relearning it.

Three of the subjects, who at the outset had requirements of 14¾, 15¾, and 11⅛, and at the last described stage, of 7¼, 8½, and 6¾ repetitions, continued the practice for sixteen more series. They required on the average, in the last four of these, 4, 5¾, and $2^{9}/_{10}$ repetitions.

Sleight ('11) had adults memorize dates, nonsense syllables, poetry, prose, the substance of paragraphs, and letters. He found substantial gains in the second series memorized over the first (there were only two series).

Schultze ('15) found that an adult mathematician of extraordinary ability in memorizing numbers (who could

learn a series of 8 six-place numbers or 40 digits in 37 seconds, for example) improved steadily with practice.

Complex Abilities

Thorndike ('08-*a*) measured the improvement of 28 adult graduate students in multiplying mentally a three-place number by a three-place number. Each one did 95 multiplications, such as 657 × 964, 398 × 367, 476 × 479. From the detailed results a reasonable estimate is that a graduate student, of age 25 to 30, after seven hours of practice will do such an example in less than two-fifths of the time he spent at the outset, and make as few or fewer errors.

These experimental results concerning adult learning are a formidable array. These adults seem eminently plastic and teachable in every mental function that was examined. However, they may not represent the truth for adults in general. They are doubtless much superior to adults in general in intelligence. This superiority might operate in one or both of two ways. It might make these individuals superior to adults in general in ability to learn in about the same ratio that these subjects were, at age 5, or 10, or 15, superior to five-year-olds in general, ten-year-olds in general, or fifteen-year-olds in general. This it probably does do; and in our thinking we should allow for it. The average pupil in a night school or correspondence course should not be expected to learn at the rate of these graduate students.

In the second place, it might make these individuals still more superior to adults in general by reason of an increasing persistence of ability to learn in relation to intelligence. That is, the abler intellects might not only have greater ability to learn, but retain it longer. For example, intellects of average degree might display ability

to learn as in the lower line of Fig. 2, below; whereas the top tenth of intellects showed the upper line as their ability to learn.

This second doctrine, that the curve of ability to learn in relation to age varies with intelligence and makes a later and slower descent in the able than in the average intellect, deserves careful attention. We need to know

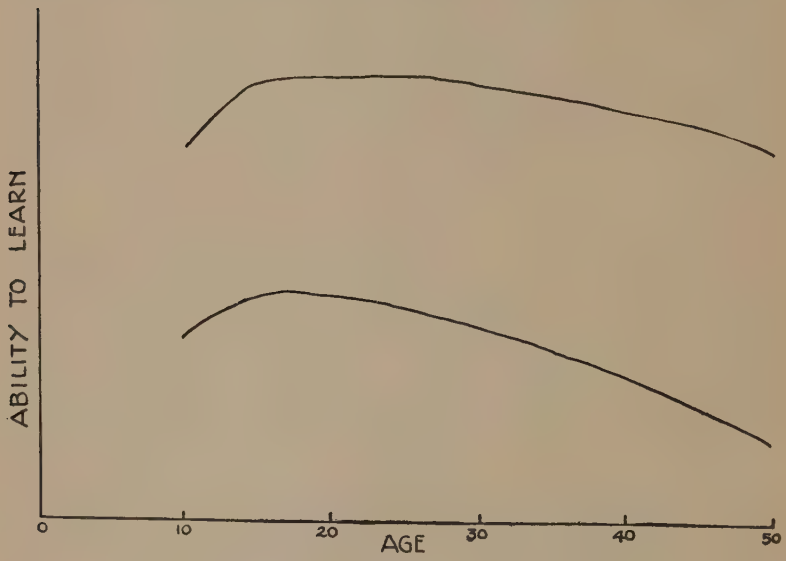


Fig. 2. Possible Curves of Ability to Learn

the truth about it not only in order to evaluate the significance of the facts of this chapter, but also in order to plan for experiments comparing the young and the old directly. If the relation of ability to learn to age is substantially alike for all degrees of intellect, we can profitably compare young and old at any intellectual level which is the same level for both; for we shall get the same result. If, however, the relation of ability to learn to age varies with the degree of intellect, we cannot use the comparison

of gifted old and gifted young in place of the comparison of average old and young, or dull old and young. We must either make these comparisons directly or allow for the different forms which the curve takes in each case.

Consequently, we have made the influence of intellect upon the curve of ability to learn in relation to age the subject of special investigations, which are reported in Appendix I, page 195. Their net result is to make it probable that the influence is very slight, that the ablest man and the ordinary man show very nearly the same curve, that the decline of ability to learn begins little, if any, later in the highest one per cent of intellects than in the average man. An allowance of two years is probably more than ample; if the decline from the prime of life toward senility begins at 55 for the average man, it does not delay beyond 57 for the man whose ability puts him at the top among a thousand. If the arrest of upward progress in general achievement occurs at 43 for the average man, it will occur before 45 for the superior man. If the arrest of upward progress in the ability to learn occurs at 21 in the average intellect, it will occur before 23 in the superior intellect. If superior intellects show nearly as great ability to learn at 30 as at 20, the same may be expected of average or inferior intellects.

These inferences from the work reported in Appendix I have been substantially verified by direct experiments to be reported in Chapters V and VI. They are noted here in order that the reader may have them in mind in interpreting the facts of this chapter and the next two chapters.

CHAPTER III

Comparisons of Adult and Youthful Learning

In the facts presented in Chapter II we have abundant evidence that certain adults learned rapidly, but lack of any measures of the learning of children or adolescents or younger adults at the same or closely similar tasks. In the experiments to be reported in the following pages we are able to make comparison of young and old learners under somewhat the same conditions. The number of individuals compared is very small in many cases; and only the general drift of the facts should be used in argument.

Simple Sensorimotor Abilities

Gonnelly, as reported by Freeman ('17, p. 150 f.), had an eight-year-old child and its parents put through a course of training in tossing shot into a tumbler 1800 times. The child's gain was about the same as the average of its parents' gains. It started with about 6 successes per hundred and rose to about 46. They started with about 32 and rose to about 86. Differences between per cents of successes are not comparable. We do not know whether a gain of 40 from 6 is a smaller or larger gain in skill than a gain of 59 from 32. We estimate from Freeman's report that the child required at least as many throws to make the gain from 32 to 46 as the adults did.

Noble ('22) had three thirty-two-year-olds and three twenty-one-year-olds practice at throwing goals with a basketball. The gain was 28.3 per cent for the former and 25.8 per cent for the latter. Noble suggests that

these may have suffered somewhat from being shorter than the older group.

Lashley ('15) studied the acquisition of skill in archery in the case of nineteen boys and men ranging from 14 to 36 years. There was no demonstrable difference in relation to age. The two oldest, aged 36 and 33, gained 29 and 4 inches respectively, or an average of 16½. The general average of the gains was 14.7. The correlation of gain with age was − .10. The older half, averaging 25.4 years gained 14.1 ± 1.9. The younger half, averaging 16.1 years, gained 15.3 ± 1.3.[1]

Snoddy ('26) has studied children, adolescents, young adults (college students), and a group of persons from 60 to 80 years old in learning to follow a path seen in a mirror. He distinguished a rapid improvement in early stages which he calls *adaptability* from a slower improvement in later stages which he calls *stability*. "It is found that the normal child of six years has a stability about 65 per cent that of an adult; a child of ten has a stability 75 per cent that of an adult; and an adolescent of eighteen years has, on the average, adult stability." ('26, p. 33)

He says of the influence of old age: "In order to throw more light upon initial adaptability, we have made a small study of aged subjects. In almost every case the standing of these subjects in adaptability is much lower than in stability, when both are compared with the same traits in our standard college group. This is so much the case in our studies that old age can be considered as involving lowered adaptability rather than lowered stability, although the latter is found in very advanced years." ('26, p. 33)

[1] These results are computed from measures estimated from Lashley's Fig. 15 ('15, p. 114)

Forming Simple Habits

Brown ('14) studied the learning of various habits of sorting cards involving the overcoming of interfering habits. He used twenty-six individuals, mostly college undergraduates, in one set of experiments and eighteen in another. In the first set of experiments there was an apparent correlation of youth with capacity for improvement, but "no such correlation appeared in the second experiment" (4, p. 315). The correlation found in the first group was probably a result of differences in intelligence. Other things being equal, the younger a person reaches college the more intelligent he is. So the younger half of any college class will be on the average more intelligent than the older.

By the courtesy of Dr. H. L. Hollingworth we have been able to use his original records of the caffein experiments, in which certain mental tasks were performed five times daily for twenty-six days, by fifteen subjects ranging from nineteen to thirty-nine years old.

We have computed from these records measures of initial ability and gain in opposites, in calculation, and in control of movement or coördination. These tasks are described by Hollingworth as follows:

Association of One Idea with Another Specific Idea

This process is represented in our experiment by the test of *Naming Opposites.* On a cardboard which lay face downward before the subject was the following list of 50 adjectives, typewritten, in two parallel vertical columns of 25 each. The instructions were to turn the card over at the given signal and proceed down the list, naming aloud the *opposite* (in meaning) to each word in the order in which it occurred. The time required for this performance was measured by the assistant in fifths of a second. In order to make the test one of association time rather than of linguistic knowledge, such errors as giving an adverb as the opposite of an adjective, etc., were pointed out.

If an unacceptable word was given the assistant exclaimed *No* and the subject was required to give a correct opposite before proceeding. The same fifty words were used at each trial, but each time they occurred in a new and chance order, determined by shuffling a deck of cards on each of which one of the words was written, and making out the typewritten list in the order in which the cards turned up.

Name the opposite of each word, in turn, as quickly as possible:

loud	fertile	vague	rash	tragic
slovenly	wise	ancient	ripe	graceful
innocent	masculine	foreign	dangerous	shallow
broad	beautiful	timid	prompt	drunk
public	sacred	harmonious	fickle	cloudy
stale	brief	coarse	aristocratic	sharp
sickly	defective	noisy	peculiar	stormy
gay	helpless	past	talkative	idle
soothing	expensive	hostile	attractive	savage
cowardly	doubtful	gentle	victorious	lazy

These words were chosen from a list of 200 which had been previously applied by Professor R. S. Woodworth to many individuals, measuring the time required to name the opposite of each word when the words were presented separately instead of serially. The above list of 50 adjectives was chosen because they all fell into the class of "moderately difficult", their average times ranging from 2 to 5 seconds.

The *Opposites Test* is a much used one in experimental and educational psychology and has been found to correlate to a fairly high degree with other tests designed to measure "mental ability." As the test is conducted the mental process is essentially one of controlled association, with the quality and quantity of the performance constant and the time variable. To think of the exact answer to a question, the precise address of a friend, the exact shade of meaning of a word, delicate distinctions of connotation in the use of language, all involve processes of controlled association, processes, in which, from many ideas which the stimulus calls up, the one appropriate idea is recognized, selected, and expressed, while the false or inadequate ideas are repressed. Hence this test indicates the ability of the individual to select the appropriate response from the host of ideas which follow in the wake of a stimulus word. It is an index of speed, accuracy, linguistic feeling, and of the ability to repress useless or irrelevant ideas. At the same time it

shows the ability of the individual to improve by practice in such a performance, as well as the regularity of that performance. It is a test of association processes, but of association processes of a considerably more complex kind than those involved in the *Color-naming Test.*

Association of an Idea with a Specific Task or Situation

A still more complex stage of association is found when a specific task or situation calls for an appropriate and immediate response. The ideas themselves are not given. The individual must provide his own ideas and images, and may manipulate them in his own way, but he must in some way come out of the process with the right response. It is thus a case of evolving an idea to meet an unexpected situation. The question will be, how quickly can the individual manipulate his mental processes so as to call up the right idea in his consciousness and set up movements of articulation which will express to an onlooker the result of his thinking. The *Calculation Test* was chosen to represent this type of association. A card was prepared containing 50 two-place numbers between 20 and 80, all numbers ending in 0 being omitted. These 50 numbers occurred in a random order, and each number occurred but once in a list. The subject was required to turn the card face upward at the starting signal, and without the aid of any graphic device, to add 17 mentally to each of the numbers on the card. The answer was to be spoken aloud and was checked up by the assistant who held the key card containing the correct answers. In case of a false calculation the subject was required to correct his answer before proceeding. The time required to perform the 50 additions was measured in fifths of a second. At the next trial the same numbers appeared on the card, but in a new random order.

Coördination — The Three Hole Test of Combined Accuracy and Speed

The three hole test, as it is technically called, includes, along with the factors of steadiness and speed, which are essentially motor or physiological, the more strictly mental factor of coördination. An oak plate tilted at an angle of 45 degrees to the base board, contained three brass-line holes arranged in the form of an equilateral triangle, about 8 cm. apart. Contact of the metal rod with the bottom of a hole made an electrical con-

nection which was recorded by the automatic counter. The subject held the rod in his left hand because the right hand had just been used for the tapping test. The task was to insert the rod into each of the three holes successively as rapidly as possible until 100 insertions had been made. The time required for this process was measured by the assistant with the stop watch in fifths of a second. Success in this test requires not only that a single set of muscles be brought into harmonious action, as in the tapping test, but also that several sets be coördinated with each other, under the guidance of a visual impression. In making the movements most of the muscles of the arm are involved, as are the external muscles of the eye and its mechanism of accommodation. Arm movements must be coördinated with eye movements as accurately and at the same time as quickly as possible. The test is thus a measure of combined accuracy and speed—it measures the efficiency with which such stability and activity as are available can be brought under the control of a purely mental effort—the coördination of a complex set of activities focused on the accomplishment of a single and definite task. The series of motor tests, of which this is the third, seems to afford significant indices of general motor capacity, and usually reveals clear cut individual and sex differences in inertia, speed, accuracy, fatigue, and rate of improvement. ('12, pp. 18-24)

The procedures involved in our calculations of gain, which are necessarily somewhat elaborate, are described in Appendix II. The gist of the results is as follows:

There were five individuals of age 19 to 24, five of age 24 to 28, and five of 33 to 39. There is only a slight difference in favor of the young in learning to say the opposites, the median times required to improve from a rate of 250 to a rate of 450 being 2807 for the youngest, 2654 for the middle, and 3376 for the oldest group.

In the addition of 17 to numbers from 20 to 80, the average number or repetitions required to improve from a rate of 160 to a rate of 320 was 12.2 for the youngest five, 11.3 for the middle five, and 13.1 for the oldest five. Here again the inferiority of the oldest group is very slight.

In the three-hole test the oldest group improves much less rapidly than the youngest group. The best utilization of the data requires the division of the fifteen persons into two groups, in one of which the number of repetitions required to produce an improvement from a rate of 1.5 to a rate of 2.5 was counted, while in the other the number of repetitions required to produce an improvement from a rate of 1.25 to a rate of 1.75 was counted. In the former there were three of age 19 to 23, three of 24 to 27, and three of 33 to 39. The average number of repetitions required was 31 for the youngest third, 59 for the middle third, and 73 for the oldest. The medians were 30, 45, and 50, respectively. In the second group the averages for the two youngest (19 and 24 years), the two middle (27 and 28 years), and the two oldest (34 and 39 years), were 40, 47, and 76 respectively. The oldest third thus take roughly twice as many repetitions as the youngest third.

Learning More Elaborate Systems of Habits

Kitson ('22 and '25) measured the improvement in typesetting (hand-composition) which occurred under a particular wage stimulus, using forty men ranging in age from 18 to 49. Dr. Tilton has computed from Kitson's records (Table XXI, p. 160 of Kitson, '25) the correlation which would be found between age and improvement in a group such as this, but identical in length of experience and in initial ability.[1] It is approximately zero ($+.036 \pm .110$).

Downey and Anderson report the acquisition of the ability to write while reading silently or aloud ('15) and the amount of retention after two years ('17) by *A*, a

[1] Dr. Tilton uses the change from the average score in the 8th and 12th week to the average score in the 16th and 20th week as the measure of gain. Initial ability is the former average. $r_{AG} = .193$; $r_{AG.I} = .164$; $r_{AG.E} = .057$; $r_{AG.IE} = .036$

man aged about 21 and 23 at the two periods, and *D*, a woman aged 39 and 41.

Comparison as to the amount of gain in the original acquisition is difficult, because the two programs were not identical.[1] As we interpret the evidence given, the older subject was at a lower absolute level throughout, but made little, if any, less gain per unit of time spent. In retention after the two years the older subject seemed to have a considerable advantage. "There is considerable retention of capacity to maintain two processes (reading and writing) after lapse of practice for more than two years, with a rapid relearning and approximation of one's last record. Subject *D* showed a quicker recovery than *A*. The records of *A* also indicate a much greater loss of capacity for handling the situation that he found the more difficult of the two utilized.

"Transfer of the practice effect appeared more evidently for *D* than for *A*." (Downey and Anderson, '15, p. 408)

In experiments in memorizing it is usually found that an individual improves his ability to memorize by practice; but there is some reason to believe that adults from about 40 on do not gain so rapidly from practice in memorizing as persons 20 to 30. Radossawljewitch ('07), as quoted by Howard, reports that the improvement from practice is greater in adults than in children. Meumann ('13) found the contrary for three adults of 36, 40, and 54, in comparison with university students. He says:

> It is especially to be noted that 3 older observers took part in all of these experiments, one of whom was 36, another 40, and the third 54 years of age. And although the effect of practice was very considerable in the case of these three observers, still it did not even approximate the amount which appears in the results of the students. At about the age of 40 years, then, it seems probable that a retrogression of memory occurs even

[1] The primary purposes of the investigation did not include any study of the rate of acquisition, much less any comparison of the two subjects.

under conditions of maximum practice. If we examine our whole group of experiments, which included observers ranging from 7 to 54 years of age, in order to determine at what age the greatest memory efficiency can be attained by an approximately equal amount of practice, we shall find that the period lying between 20 and 25 years is the optimal age of memorial efficiency. ('13, p. 359)

Complex Abilities

Joseph Peterson ('18) measured the ability of eighteen persons to learn a matter which required a mixture of reasoning and memory, as follows:

> The experimenter in giving the 'tests', as they were called in talking about them to the subjects, sat at a table opposite the subject shielded from the view of the latter by a screen. The experiments were carried out in a quiet room by the writer. The following instructions were given each subject: "This is a memory-reason test. The letters A, B, C, D, E, F, G, H, I, and J are numbered in a random order from 1 to 10. I call out the letters in their order and you are to guess numbers for each letter till you get the correct number, when I say 'Right'. Then I call out the next letter, and so on. This is continued till you get each number right the first guess twice in succession through the series, from A to J. Then you are through. *You must ask no questions*, but are to use all the mental powers at your command. You will be judged by the number of errors (or wrong guesses) you make and the number of repetitions from A to J required." (Peterson, '18, p. 446)

The subject was left free to use any method in establishing the associations that occurred to him. Ten of the learners were college students; one was a high school student. The other seven were older, comprising a college instructor, two graduate students, an electrical engineer, a doctor, a woman of fifty (a high school graduate) and a bond clerk. The older group did somewhat better than the younger. The average number of trials necessary was 5.0 for them and 7.2 for the younger group. The average number of errors was 139 for them and 243

for the younger group. There were three of the younger group worse than the woman of 50.

Learning by Analysis and Selection

John C. Peterson ('20) measured the ability to learn a mathematical game[1] shown by a group of instructors and graduate students, two groups of college students, and two very able boys, one of 13, the other of 11. The boy of 13, of whom his mathematics teacher said, "I believe that he is the brightest boy I have ever known," learned as well as the ablest of the graduate group. He required less time but more trials.

[1] "The problems whose solution constituted the task of our subjects were found in a simple game which proved susceptible of easy expansion and adaptation to the needs of the present study. The original game calls for the presentation of a number of matches, say 14, from which two persons draw alternately, each being permitted to take 1 or 2 matches at a draw. He who manages to get the last draw wins the game. . . . Now when the initial number of beads is 14, *S* can always win the game by taking 2 beads at his first draw and enough at every draw thereafter to make the sum of each of his own draws and *E*'s preceding draw equal to 3. In this manner he reduces the sum of beads successively to 12, 9, 6, 3, and 0, thereby securing for himself the *last draw* and so winning the game.

The mastery of this simple game constitutes a problem the solution of which involves some learning, as is indicated by the fact that a group of senior college students required 50.6 trials on the average for the winning of two successive trials. Each trial consists of the subject's responses to a series of situations which vary slightly though regularly as will be explained later. The learning process consists in finding the correct response for each situation and in connecting every situation with its appropriate response. When the objective situations and responses are recorded, it becomes possible to trace the progress of learning from trial to trial until any required degree of mastery of the problem is attained.

When a single problem of this sort is solved, the solution is usually couched in more or less specific terms which do not readily function in the subsequent solution of other similar problems. In the solving of a series of related problems, however, it is possible to observe the gradual abstraction of common elements and the association of these elements with appropriate terms, leading finally to the formulation of a general principle for the solution of all problems of the series. If the mastery of 14 as the initial number of beads constitutes the first problem, mastery of 15 as the initial number will constitute the second problem, mastery of 16 as the initial number the third, and so on until enough problems have been solved to permit the subject to develop a general formula for his guidance in drawing from any number of beads." (J. C. Peterson, '20, p. 3 f.)

An eleven-year-old boy (*K*) and his father (*J*, a doctor of philosophy) were tested with a series of trials of the game. *K* learned 76 problems in 146 trials, his father learned 81 problems in 116 trials. Peterson writes:

The only difference in the procedure with these two subjects was that *J* did the work in two sittings on successive days whereas *K* worked five successive days but with much shorter periods. It does not seem probable, however, that the relative speed of progress of the two subjects was seriously affected by this difference in the length of periods of work, since *J* stopped work in each instance as soon as he began to feel fatigued. . . .

There is no marked difference in the work of these two subjects. They required the same number of trials for the first series, after which *K* took the lead throughout all of the remaining continuous series but was surpassed by *J* in the discontinuous series. However, the lead established here by *J* was so small that it might easily have been lost if the work of the two subjects had continued further along parallel lines. (J. C. Peterson, '20, p. 101 f.)

Ballard ('15) tested eleven individuals, including representatives of three generations of one family, of two generations in another, and of ages from 6 to 70, with five groups of puzzles,[1] each done under five sets of conditions (*a*) without directions, (*b*) after learning the direc-

[1] The puzzles as described by Ballard ('15, p. 56 f.) were:

GROUP I. — MATCH PUZZLES. — *Puzzle I.* — Matches were laid in 16 squares. . . . The problem was to remove only four matches and leave twelve of the original squares. There are several ways of doing this, the simplest of which is to remove the four matches in the center of the figure.

Puzzle II. — Matches were laid in six squares. . . . The problem was to remove five of the matches so as to leave three complete squares. . . .

GROUP II. — GEOMETRICAL PUZZLES. — *Puzzle III.* — Five pieces of cardboard were laid in a strip. The problem was to rearrange them all so as to form a perfect square.

Puzzle IV. — Four pieces of cardboard were arranged in the form of a square. . . . The problem was to rearrange them in the form of a cross.

In both of these geometrical puzzles the cardboard was colored differently on the back side to prevent the reagent inadvertently turning a piece over, which would in most instances make it impossible to solve the puzzle.

GROUP III. — TRACING PUZZLES. — *Puzzle V.* — A figure. . . was placed under a ground glass cover in a wooden frame, and the reagent was asked

tions, (*c*) after reading the directions, (*d*) after seeing the puzzle done by another, and (*e*) after doing the puzzle himself with aid from the experimenter. After seven days without warning the entire procedure was repeated.

The ages were 13, 14, 17, 25, 28, 34, 35, 45, and 70. The 13-year-old and the 14-year-old were very bright children; the 17-year-old was a mischief maker and a failure in scholarship. He was next to the best in the puzzles.

Ballard does not attempt to measure the influence of age beyond noting that the 70-year-old's record was "unexpectedly good in view of her advanced age" and the 6-year-old (her grandchild) made a record that was "surprising" for the number of successes: *Bl*, the 13-year-old son of *Pd*, did better than his father. *Mg*, age 34, the daughter of *Gm*, the woman of 70, did better than her mother.

We have computed an impartial, though crude, index of the degree to which each individual profited by the experience of the first session by taking the median time required for the unaided solutions of the eleven puzzles at the beginning of the second session. We omit the eleventh case, which was one of marked mental defect, and the 6-year-old child. The correlation with age is − .14.

to trace the entire figure in an unbroken line without going over any part more than once.

Puzzle VI. — The same problem as in Puzzle V, except with a different and considerably more difficult figure to trace. . . .

Group IV. — Maze Puzzles. — *Puzzle VII.* — A rectangular maze was placed in the frame under the glass and the reagent was asked to trace an unbroken path through the open spaces from the outside of the maze to the center. . . .

Puzzle VIII. — The same problem as in Puzzle VII, except with a more difficult maze. . . .

Group V. — Metal Puzzles. — *Puzzle IX.* — Two heavy wire loops resembling horseshoes . . . were placed in the hands of the reagent to be taken apart.

Puzzle X. — Two twisted nails . . . were given the reagent with instructions to take them apart.

Puzzle XI. — Two keys fastened together by their squares . . . were laid before the reagent, who was asked to take them apart,

We have also computed the median time at the very end of the first day's session and correlated this with age. The correlation is — .22. If we attach equal weight to the two times, the correlation is — .16.

The Transfer of the Effect of Training in One Mental Ability to Other Abilities in Relation to Age

The only data available are those of Rugg. Rugg ('16) experimented with 413 students of the University of Illinois of ages from 17 to 26 concerning the influence of training (descriptive geometry) upon more general abilities in dealing with space facts and relations. Rugg concludes that "within the limits represented by the study (17 to 26 years) the age of the subject does not seem to be a factor in determining the effect of training on his ability in the mental manipulation of spatial elements." ('16, p. 115) Of those 17 to 20 years old, 280 gain and 185 do not (60.2 per cent and 39.8 per cent). Of the subjects 20 to 26 years old , 252 gain and 153 do not (62.5 per cent and 37.5 per cent). Comparing the subjects younger than 18 with those over 22, the per cents gaining are 64.4 and 57.8, respectively. Since the younger students in such a group are likely to be somewhat more intelligent than the older, and since there is likely to be a correlation of intelligence with gain, the probability is that, if the age groups were equalized in respect of intelligence, the older men would maintain their equality with the younger or even gain somewhat more.

It is not necessary to make a general estimate of adult learning from the experiments reported in this chapter. That can be done very much better from the much more extensive experiments to be described in Chapters IV to VIII.

We may, however, note three facts: (1) The differences in rate of learning between old and young are small in comparison with the differences within either group. (2) When other factors than age are equalized or "partialed out," the influence approaches zero. (3) If each author is given equal weight, we have an equal division among reports of superiority, inferiority, and equality of the adult learner. If we attach, as we should, more weight to the experiments which report learning during a long period or for many individuals, we get about the same balance. On the whole, if we did have to estimate on the basis of this chapter's reports, we should estimate adult ability to learn as very close to that of the late teens.

CHAPTER IV

New Experiments on Adult Learning: Learning by Adults of Superior Intellect

The facts reported in Chapters II and III obviously need to be supplemented if we are to determine with precision the difference between adult and youthful ability to learn. More measurements of the rate of learning are needed; and measurements of the intelligence of the learners are needed so that we may compare old with young of equal intelligence. Measurements of learning in the case of average and dull adults and young people are needed as a check of our inference that age influences the curve of ability to learn similarly at all levels of intellect.

We have carried on three extensive series of experiments, each including two hundred or more learners and covering long periods of learning. The first concerns learning to read, write, compute, and form certain simple habits in the case of adult prison inmates, covering a range of intellect from near the average to very low levels. The results of this will be the topic of Chapter V. The second concerns learning of typical high-school subjects, such as algebra, English, civics, and biology in the case of adult pupils in public evening high schools, covering a range from near average to very high levels. This will be the topic of Chapter VI. The third concerns learning typewriting and stenography in the case of adult pupils in secretarial schools, covering a range of intellect from near the average to very high levels. This will be the topic of Chapter VII.

We have also carried on intensive experiments in learning to write with the wrong hand, to typewrite, and to understand the artificial language, Esperanto. These will be reported in the present chapter.

Learning to Write with the Wrong Hand

Six individuals who had always written with their right hands undertook to learn to write with the left. Two individuals who had always written with their left hands, save for a very brief period in early childhood, when at school an attempt was made to teach them to use the right hand, undertook to learn to write with the right hand. Throughout all the work the same kind of ruled paper and the same pen was used. The experiment consisted of a preliminary test of forty minutes, divided into four periods of ten minutes each with five minutes rest; thirty practice periods of thirty minutes each; and a final test identical with the preliminary test. The material for the tests is shown below. The material for the practice was consecutive copy from the Journal of Educational Psychology, such as contained no irregular material and no numbers.

The ages of the subjects at the time of beginning the experiment were: *B*, 34 yr., 1 mo.; *D*, 33 yr., 1 mo.; *F*, 52 yr., 3 mo.; *K*, 22 yr., 3 mo.; *L*, 42 yr., 4 mo.; *R*, 28 yr., 4 mo.; *S*, 28 yr., 1 mo.; *V*, 41 yr., 4 mo.

Test Material for Writing with the Wrong Hand

Rests of 5 minutes between Parts 1 and 2, between Parts 2 and 3, and between Parts 3 and 4.

Part 1. 10 minutes

At the signal "Go" begin to write, being careful to make as nearly perfect work as you can.

First write in small letters:

one two three four five six seven eight nine ten eleven twelve thirteen fourteen fifteen sixteen seventeen eighteen nineteen twenty

Then write:

Monday Tuesday Wednesday Thursday Friday Saturday Sunday

Then write:

January February March April May June July August September October November December

Then write:

My country 'tis of thee,
Sweet land of liberty,
Of thee I sing.
Land where our fathers died,
Land of the pilgrims' pride,
From every mountain side
Let freedom ring.

Then repeat the above until time is called.

Part 2. 10 minutes

Copy as much of Journal of Educational Research, Vol. XI, No. 1, pp. 1 and 2 as you can. being careful to do as nearly perfect work as you can.

Part 3. 10 minutes

Repeat Part I.

Part 4. 10 minutes

Copy as much of Journal of Educational Research, Vol. XI, No. 1, pp. 3 and 4 as you can, being careful to do as nearly perfect work as you can.

The quality of each specimen of writing was measured approximately in terms of the Thorndike Handwriting Scale, there being always at least ten judgments of the specimen. The median Thorndike score was used as a quality measure. The amount written was measured, in the case of the early and late tests, by a count of the

number of letters. The amount written in the practice periods was measured by the number of lines written. The scores in the early and late tests and in the practice periods are shown in Tables 4, 5, and 6. The most important results of the experiment were as follows:

TABLE 4

The results of tests before and after 15 hours of practice in writing with the wrong hand: eight adults. F and L were left-handed and used the right hand in the experiment.

		Rate: In Letters per Minute				Quality: In Units of the Thorndike Scale				Total Letters in 40 Min.	Average Quality
		Mem. 1	Copy 1	Mem. 2	Copy 2	Mem. 1	Copy 1	Mem. 2	Copy 2		
B	Early	25.4	30.5	35.4	34.6	7.0	6.5	7.0	7.0	1259	6.9
	Late	69.1	63.4	73.7	70.7	7.0	7.0	7.0	7.0	2769	7.0
	Diff.	43.7	32.9	38.3	36.1	.0	+.5	.0	.0	1510	+.1
D	Early	32.3	33.3	32.3	39.1	8.0	7.7	8.0	8.0	1370	7.9
	Late	80.9	74.3	84.0	80.2	7.8	7.3	7.5	8.0	3194	7.7
	Diff.	48.6	41.0	51.7	41.1	−.2	−.4	−.5	.0	1824	−.3
F	Early	36.3	51.5	57.6	56.4	7.4	7.5	7.8	7.9	2018	7.7
	Late	82.0	83.8	97.1	85.5	7.5	7.0	7.0	7.0	3484	7.1
	Diff.	45.7	32.3	39.5	29.1	+.1	−.5	−.8	−.9	1466	−.5
K	Early	36.9	28.4	25.0	22.5	6.5	7.7	7.5	7.5	1128	7.3
	Late	66.9	69.3	73.8	78.2	7.0	7.5	8.0	8.0	2882	7.6
	Diff.	30.0	40.9	48.8	55.7	+.5	−.2	+.5	+.5	1754	+.3
V	Early	46.9	47.9	53.3	49.7	5.0	5.7	5.5	5.5	1978	5.4
	Late	78.5	77.2	97.1	79.5	5.0	5.0	5.0	5.0	3323	5.0
	Diff.	31.6	29.3	43.8	29.8	.0	−.7	−.5	−.5	1345	−.4
L	Early	26.3	30.5	34.2	34.6	8.0	8.5	9.0	8.5	1256	8.5
	Late	46.4	39.2	47.5	42.4	11.0	10.5	9.5	10.3	1755	10.3
	Diff.	20.1	8.7	13.3	7.8	+3.0	+2.0	+.5	+1.8	499	+1.8
R	Early	33.7	39.2	37.6	36.7	7.5	8.0	7.0	7.5	1472	7.5
	Late	54.2	57.1	59.9	66.8	9.0	9.0	9.0	9.0	2380	9.0
	Diff.	20.5	17.9	22.3	30.1	+1.5	+1.0	+2.0	+1.5	908	+1.5
S	Early	30.6	31.7	33.7	31.3	5.0	6.0	7.0	6.7	1273	6.2
	Late	55.3	52.3	61.3	65.3	8.0	7.5	8.5	8.0	2342	8.0
	Diff.	24.7	20.6	27.6	34.0	+3.0	+1.5	+1.5	+1.3	1069	+1.8

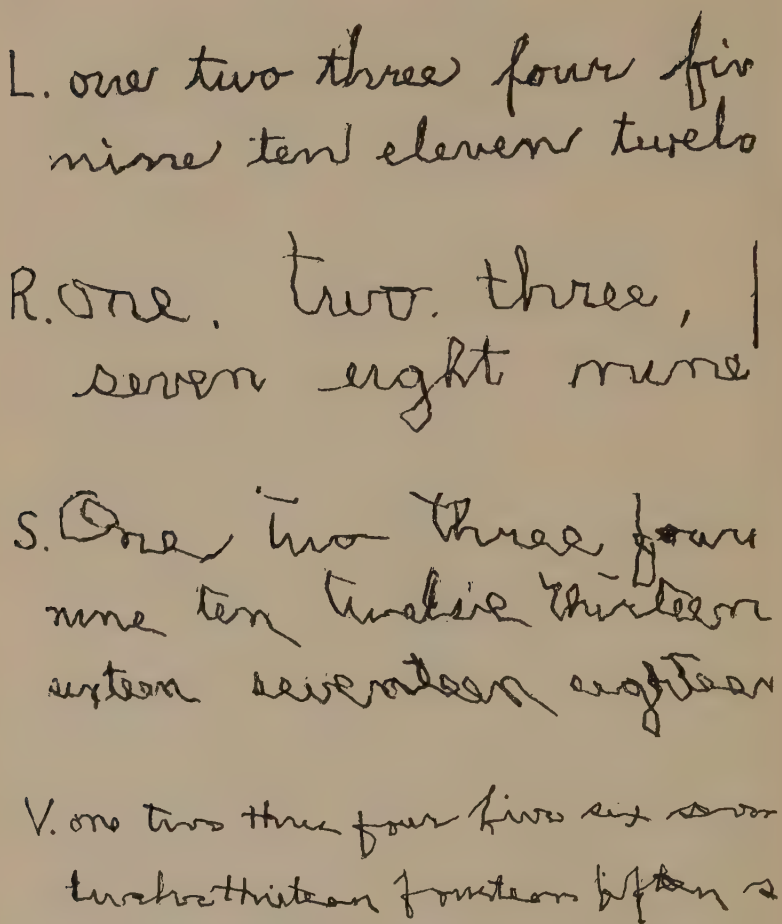


Fig. 3A. First Wrong-hand Writing of Eight Adults.

From the very start the subjects were able, with the aid of the control of vision, to make recognizable letters; to join these into recognizable words, and to place these words fairly accurately on the lines. A reproduction of the first line as written by each subject appears as Figure 3,

page 36 and 37. This fact is of much general significance. When one changes the hand in writing, not only do none of his old habits of movement fit the new demand; they are distorted in a complicated way. Nevertheless, the mere general control given by knowledge of the desired appearance and by vision enables the adult learner to counteract

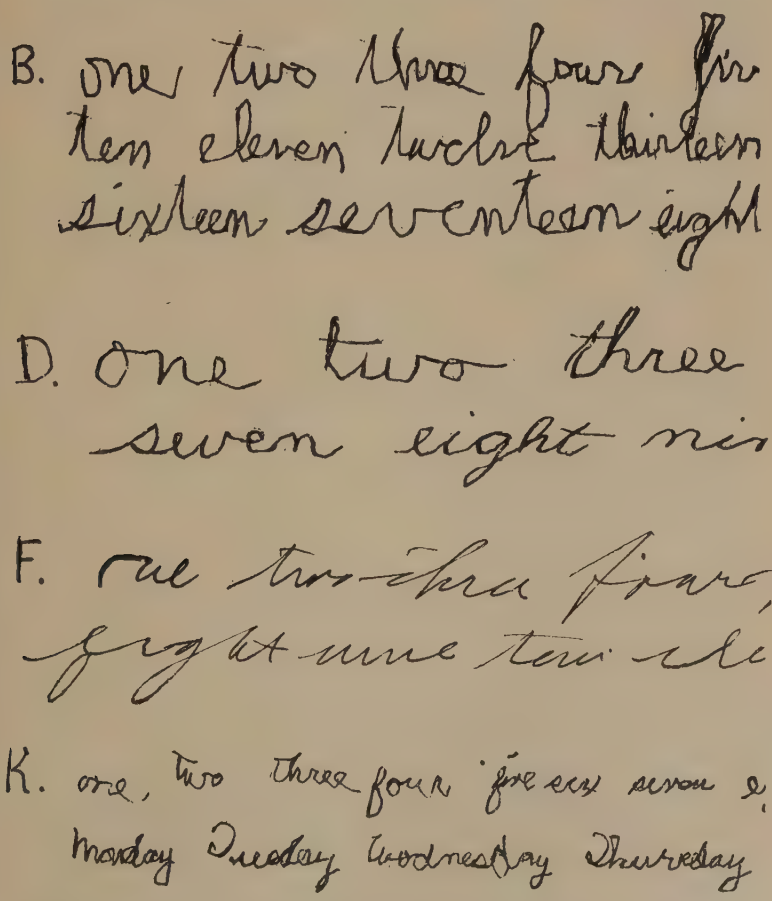


Fig. 3B. First Wrong-hand Writing of Eight Adults.

tendencies to write in mirror fashion, and to establish rather quickly a new hierarchy of habits. It is of course true that at the beginning the letters and words are *drawn* rather than written, and also that there are irregularities and erroneous movements which show that the control is not perfect. The general fact remains that somehow the adult starts in writing with the wrong hand with

TABLE 5

Summary of the facts of Table 4 in relation to age

INDIVIDUAL	AGE	SCORE IN INTELLIGENCE CAVD	Initial		Final		Gain	
			LETTERS PER MINUTE	QUALITY	LETTERS PER MINUTE	QUALITY	LETTERS PER MINUTE	QUALITY
K	22	433	28	7.3	72	7.6	44	.3
S	28	421	32	6.2	60	8.0	27	1.8
R	28	430	37	7.5	60	9.0	23	1.5
D	33	421	34	7.9	80	7.7	46	−.3
B	34	...	31	6.9	69	7.0	38	.1
V	41	423	49	5.4	83	5.0	34	−.4
L	42	424	31	8.5	44	10.3	13	1.8
F	52	426	50	7.7	87	7.1	37	−.5

nearly as great facility as the child of eight or nine has in writing with the right hand after two years of schooling.

Within the short period of fifteen hours of practice, plus forty minutes allowance for the practice effect of the tests themselves, those subjects who maintained substantially the same quality of handwriting, much more than doubled their speed. Those subjects who worked for a higher quality obtained it and still made very substantial gains in speed. Three of the subjects gained respectively, 1.5, 1.8, and 1.8 points on the Thorndike Scale. These

TABLE 6

Writing with the wrong hand. Scores in 30 successive practice periods.

Period	Subject B		Subject D		Subject F		Subject K		Subject V		Average B D F K V		Subject L		Subject R		Subject S		Average L R S	
	Lines	Quality	Lines	Quality	Lines	Quality	Lines	Quality	Lines	Quality	Lines	Quality	Lines	Quality	Lines	Quality	Lines	Quality	Lines	Quality
1	18.4	7.5	22.4	7.5	22.3	8.0	15.9	7.0	25.5	5.5	20.9	7.1	18.5	8.5	18.3	7.5	24.0	7.5	20.3	7.8
2	20.0	6.5	27.0	7.5	28.0	8.0	20.4	7.5	26.4	5.7	24.4	7.0	21.6	8.5	21.0	7.8	23.0	7.0	21.9	7.8
3	22.9	6.5	29.5	7.8	22.5	8.5	20.0	7.0	28.3	5.0	24.6	7.0	18.8	10.0	18.3	7.5	23.5	8.0	20.2	8.5
4	24.3	6.5	28.8	7.3	24.8	8.5	22.2	7.8	30.6	5.5	26.1	7.1	23.1	9.5	22.3	9.0	25.0	8.0	23.5	8.8
5	25.5	7.0	29.2	7.5	26.0	8.5*	26.2	7.5	28.5	5.0	27.1	7.1	21.6	9.0	18.6	8.5	24.0	7.0	21.4	8.2
6	26.8	6.0	30.3	6.8	27.0	8.5	26.0	7.8	30.5	5.5	28.1	6.9	21.0	9.0	17.8	9.0	26.7	7.5	21.8	8.5
7	25.8	6.5	32.2	7.5	26.5	8.0	26.6	7.5	31.8	5.5	28.6	7.0	20.7	10.0	21.0	8.5	26.1	7.5	22.6	8.7
8	28.7	6.3	33.4	7.0	24.3	8.5	26.0	8.0	33.5	5.5	29.2	7.1	23.0	9.8	22.6	9.0	26.4	7.5	24.0	8.8
9	28.9	7.0	30.7	7.5	24.1	9.0	28.6	7.0	32.9	4.6	29.0	7.0	23.1	11.5	24.3	8.3	27.0	8.0	24.8	9.3
10	28.3	7.0	31.8	7.5	27.0	8.0	28.7	7.0	31.3	5.0	29.4	6.9	22.7	10.0	23.5	8.0	27.0	8.0	24.4	8.7
11	30.6	6.0	34.9	7.0	24.0	9.0	30.0	8.0	33.0	5.8	30.5	7.2	19.3	11.0	21.9	8.5	26.5	8.0	22.6	9.2
12	31.2	6.5	35.2	7.5	25.0	8.5	31.2	7.5	32.5	5.3	30.6	7.1	24.5	10.3	23.2	9.0	27.9	8.5	25.2	9.3
13	29.7	6.5	35.6	8.0	25.5	9.0	31.4	8.0	35.5	5.0	31.5	7.3	22.5	10.5	26.1	9.3	28.0	8.0	25.5	9.3
14	30.8	7.0	34.3	8.0	25.5	8.0	34.8	8.0	36.0	5.0	32.5	7.2	21.6	10.5	22.2	9.0	30.0	8.3	24.6	9.3
15	30.6	6.5	36.4	8.0	27.5	8.0	31.8	7.5	37.9	5.8	32.8	7.2	20.4	10.0	22.9	9.0	29.2	8.0	24.2	9.0
16	32.6	7.0	34.6	7.8	31.0	8.0	35.2	8.0	34.7	5.0	33.6	7.2	21.9	10.5	17.0	10.0	31.2	9.0	23.4	9.8
17	31.5	7.5	37.3	7.0	28.1	8.0	36.1	7.5	39.1	5.5	34.4	7.1	20.8	10.0	17.3	10.0	29.2	7.8	22.4	9.3
18	31.8	7.0	34.3	7.0	31.0	8.5	35.1	8.0	37.9	5.5	34.0	7.2	23.8	10.0	18.2	10.0	28.0	8.0	23.3	9.3
19	32.5	7.5	37.2	8.0	28.5	8.5	33.6	7.5	36.6	4.5	33.7	7.2	22.4	9.5	19.3	10.0	31.0	8.0	24.2	9.2
20	30.3	7.0	38.9	7.5	31.5	8.5	34.4	7.5	37.3	5.0	33.9	7.1	20.0	10.5	20.7	10.0	28.9	8.0	23.2	9.5
21	32.8	7.5	41.1	8.0	35.1	8.0	35.3	7.5	38.9	5.0	36.6	7.2	21.6	10.0	19.1	11.0	29.9	8.5	23.5	9.8
22	32.3	7.0	39.8	8.0	38.7	8 0	35.5	7.5	38.2	5.5	36.9	7.2	27.6	9.3	20.8	10.5	28.7	9.0	25.7	9.6
23	34.0	6.8	40.4	7.5	35.1	7.5	34.4	7.0	39.4	5.8	36.7	6.9	24.1	9.8	22.8	10.0	28.1	8.3	26.3	9.4
24	33.2	6.9	40.4	7.4	41.6	7.5	34.8	7.5	39.4	4.5	37.9	7.0	23.9	10.0	28.9	8.5	28.3	8.0	27.0	8.8
25	32.3	7.0	42.0	7.7	39.5	7.5	34.4	7.5	39.4	5.0	37.5	6.9	23.1	10.0	23.5	9.0	30.5	8.5	25.7	9.2
26	33.1	7.3	37.3	7.5	37.5	7.0	40.1	7.5	38.0	5.0	37.2	6.9	19.3	11.0	27.3	10.3	30.9	8.0	25.8	9.8
27	34.7	7.0	40.4	7.5	37.3	7.0	36.3	8.5	38.0	4.5	37.4	6.9	23.1	11.0	27.1	9.5	28.9	8.0	26.4	9.5
28	32.7	7.0	39.3	7.8	38.0	8.0	36.9	7.8	39.0	5.3	37.2	7.2	21.0	10.0	30.2	9.0	30.0	8.0	27.1	9.0
29	33.5	7.1	40.9	7.5	38.7	7.0	37.5	6.5	38.6	5.0	38.0	6.8	23.9	10.0	27.2	9.0	31.2	8.8	27.4	9.3
30	31.1	7.3	39.1	8.0	41.6	7.0	37.1	6.5	42.5	4.8	38.3	6.7	22.4	10.0	25.6	10.0	34.7	8.0	27.6	9.3

* Estimated from imperfect records. The work was interrupted.

three individuals improved in speed from an average of 33 letters per minute written in the early test to 54 letters per minute written in the late test. In general the gain of these eight adults from less than sixteen hours of practice was greater than the gain proposed by experts as suitable to be accomplished by children using the right hand in two years of growth and schooling, including one hundred or more hours of special practice in handwriting.[1]

All of the eight subjects found the work attractive and would gladly have continued further. This is doubtless in part because of the scientific and personal interest in seeing how much one can gain and under what circumstances the gain is made. Yet, in the writer's opinion, a good deal should be allowed for a more general interest in activity and improvement. The motives for improvement in this group presumably were not so strong as the motives in the case of an adult group forced to learn to write with the wrong hand because of accident. Little is known about the strength of motives in the case of men and women who have learned a new trade or to operate a new machine or the like. However, in so far as they are reasonable persons, the economic motive with them should be much stronger than the mere motive of scientific curiosity and personal interest in our group. Any group of individuals of capacity for sensorimotor learning equal to the capacity of our group of eight, should then be able to learn new trades, new features of a trade, new games of skill, and the like, with a degree of success comparable to that observed in this experiment.

An experiment like the one just described in all respects save that the fifteen hours of practice were divided into

[1] Freeman proposes 36 letters per minute at a quality equal to 8.0 on the Thorndike Scale for Grade II and 56 letters per minute at a quality equal to 9.1 on the Thorndike Scale for Grade IV. The adults of our group start at about 36 letters per minute and either gain an average of 21 letters per minute with an average gain in quality of 1.7 or gain an average of 40 letters per minute with a maintenance of quality.

ninety periods of ten minutes each, and that the individuals were instructed to try to improve both in speed and in quality, was carried out with thirty-three adults, sixteen of ages 20 to 25, one of age 32, and sixteen of ages 35 or over. All were right-hand writers; all were university students.

The results with this group are summarized in Table 7. The detailed facts are given in Appendix III. They confirm those stated above. Although, as we shall see, the individuals of 35 years or older did not gain so much as those 20 to 25 years old, their average gain was 16½ letters and a quality improvement of 1.3 points on the Thorndike Scale, which is close to Freeman's standard for two years of progress from Grade II to Grade IV, namely 20 letters per minute and 1.1 Thorndike Scale points. There are no records of children learning to write with the wrong hand. It is to be hoped that some one will repeat our experiment with children of ten and adolescents of fifteen. It is highly improbable that the former will learn as fast as our forty-year olds or the latter as fast as our twenty-two-year olds.

This second experiment enables us to measure the difference between persons of age 20 to 25 and those 35 or over. We shall include the record of *K* with the former and the records of *V*, *L*, and *F* with the latter. *S*, *R*, *D*, and *B*, of the first experiment may be combined with individual 32 of the second to make a group of age 26 to 34.[1]

The gain in quality is a little greater for the oldest group, the average gains being, in order of age, + 1.11, + .96, and + 1.16. In letters per minute the advantage is clearly with those 20 to 25 years old, the average gains being 35, 32, and 18.[2] If we count a gain of .1 of a

[1] This combination is probably slightly to the disadvantage of the older groups, since the thirty-minute practice periods of the first experiment are probably not so favorable as the ten-minute periods.

[2] The mean square errors of the 1.11, .96, 1.16, 35, 32, and 18, are respectively .198, .394, .217, 2.16, 3.21 and 2.15.

Thorndike Scale point of quality as equivalent to a gain of 2 letters per minute we have 57, 51, and 41 as the scores for the three groups. From 22 years to 42 years there is

TABLE 7

Summary of the results of tests before and after 15 hours of practice in writing with the wrong hand.

			Initial		Final		*Right* hand		Gain	
INDIVIDUAL	AGE	INTELLIGENCE CAVD	LETTERS PER MIN.	QUALITY	LETTERS PER MIN.	QUALITY	LETTERS PER MIN.	QUALITY	LETTERS PER MIN.	QUALITY
16	20	411	43	6.3	80	7.0	118	10.5	37	.7
17	20	402	40	6.6	88	7.3	152	11.4	48	.7
18	21	436	45	7.6	75	9.2	128	11.6	30	1.6
19	21	413	44	6.1	82	7.6	128	12.1	38	1.5
20	21	419	41	6.1	73	8.3	117	12.9	32	2.2
21	22	410	43	7.8	74	8.4	123	13.0	31	.6
22	22	438	30	8.4	70	9.8	123	12.4	40	1.4
23	22	412	29	6.4	77	7.4	105	13.4	48	1.0
24	22	432	33	6.8	64	7.8	117	9.4	31	1.0
25	22	447	28	7.6	53	8.6	103	12.9	25	1.0
26	23	408	35	6.9	64	8.3	98	12.5	29	1.4
27	23	397	49	6.5	65	8.7	127	13.0	16	2.2
28	23	402	47	7.0	73	9.2	155	11.5	26	2.2
29	24	406	44	6.5	74	8.4	143	12.8	30	1.9
30	24	435	37	6.5	75	6.7	127	10.9	38	.2
31	24	419	47	7.8	96	6.8	159	12.3	49	−1.0
32	32	424	39	6.1	64	7.8	145	11.9	25	1.7
33	35	402	39	6.3	53	8.4	142	9.8	14	2.1
34	36	432	34	6.8	54	8.5	120	10.5	20	1.7
35	37	415	43	7.3	51	8.6	94	13.3	8	1.3
36	37	423	31	7.4	41	9.3	70	13.8	10	1.9
37	37	403	38	6.0	46	8.2	89	9.8	8	2.2
38	38	414	32	8.9	57	9.4	122	12.0	25	.5
39	39	424	38	6.3	62	7.2	140	11.8	24	.9
40	40	406	38	7.2	40	9.7	105	11.5	2	2.5
41	41	434	32	6.5	41	7.6	84	11.1	9	1.1
42	42	412	47	7.6	64	9.7	73	12.1	17	2.1
43	42	428	32	7.6	57	8.3	132	13.4	25	.7
44	43	417	30	5.8	51	7.3	101	11.1	21	1.5
45	44	404	38	6.2	44	7.8	81	14.7	6	1.6
46	45	422	27	6.9	47	8.4	96	14.2	20	1.5
47	47	422	48	7.7	68	8.2	122	9.0	20	.5
48	57	422	36	7.0	59	6.1	92	8.4	23	−.9

a drop of 16 letters per minute. So far as our small intermediate group's records may be trusted, the drop per year is a little slower from 22 to 31 than from 31 to 42.

It should be noted that the comparison between these age groups is not invalidated, or much complicated, by differences in intelligence or in initial status in the wrong-hand writing. The average *CAVD* intelligence scores are 416 for the youngest, 424 for the medium, and 418 for the oldest group. The average initial rates are 39 for the youngest, 35 for the medium, and 37½ for the oldest group. The average initial quality scores are 7.0, 6.9 and 7.0.

It may be noted also that the youngest group writes much faster than the oldest group when the *right* hand is used. The averages are 127 and 104 letters per minute and the quality of the young group is a little better (12.0 to 11.7). We shall find elsewhere further evidence that the slowness which is proverbially characteristic of old age develops gradually through a long period.

Learning to Typewrite

Four individuals who had had with one exception little or no experience with the typewriter had an hour's explanation of the machine, a test of 40 minutes in four equal periods with five minutes rest between, sixty practice periods of 30 minutes each spread over three weeks, and a repetition of the test. The material for the tests was the same as that described on pages 33f. in the case of the wrong-hand writing. The material for the practice was an elementary book on education. One other individual (Wo) took the test before and after 30 practice periods of 30 minutes each. A count was kept of the number of errors made and a composite score for the practice periods was made by subtracting 0.1 line for each error. The initial and final test results appear in Appendix III. The

ages of the subjects at the time of beginning the practice were: Bre, 35 yr. 11 mo.; Ho, 32 yr. 0 mo.; Me, 38 yr. 7 mo.; Y, 23 yr. 11 mo.

The results of this experiment confirm Pyle's results from adult summer-session students, in showing records of progress which will compare favorably with those obtained in commercial high schools from younger students.

Learning a Systematic Logical Subject

We have conducted extensive experiments in the learning of the artificial language, Esperanto. It was chosen primarily because it represents the learning of a coherent, consistent, intellectual, logical system, and whatever is true of learning it may be expected to be applicable in large measure to the learning of other highly systematic and intellectual things such as Latin, Greek, French, German, Italian, and other languages; algebra, trigonometry, calculus, and other features of mathematics; physics, chemistry, astronomy, and other physical sciences; botany, physiology, economics, psychology, sociology, education, and other biological and social studies, in so far as these can be learned as systematic organized facts and principles.

Learning Esperanto has the additional merit for our purposes that fifteen or twenty hours of learning can cover the general nature of the system, and face a fair sampling of the essential problems of learning the language as a whole. Within so short a time a similar experiment with a natural language or with any large fraction of a science, or with any broad topic in mathematics, could not be made.

Moreover, individuals from twenty to forty are more nearly on an equality of preparation for Esperanto than they would be for any natural language or branch of mathematics or science. They are, of course, not equal.

Variations in knowledge of language and of particular languages are great and make learning much easier for some than for others. Also, some individuals start their learning at a point in advance of the others. But these differences seemed likely to be less in Esperanto than in any unit of a natural language, science, or mathematics.

We considered making up for our experimental work a brief intellectual system wholly independent of any of the existing sciences, of which all learners would have little and equal knowledge at the start, and in learning which very little of the stock varieties of human knowledge would be of specific help. A system of ethics from the point of view of the domestic cat or an artificial agglutinative language using nothing of Indo-European syntax or vocabulary are samples of the sort of material contemplated. But on the whole it seemed better to use Esperanto.

The main experiments were with two groups of 15 and of 33 university students ranging from 20 to 57 years of age. The amount of time spent was twenty hours, ten being in class and ten in individual study. All had the same teaching.[1] Progress was measured by the difference in score between a series of four tests (in vocabulary, printed directions, oral directions, and paragraph reading) given before any study and after the twenty hours. We compared the average gains of eighteen individuals who were 20 to 25 years old, nine individuals who were from 26 to 34, and twenty-one individuals who were 35 or over. These three groups were of almost equal ability in a standard intelligence test. The facts are given in detail in Appendix IV.

The 20- to 25-year group gained 31.5. The 26 to 34 group gained 26.3. The 35 or over group gained 24.7[2]

[1] These experiments were conducted by Dr. L. H. V. Kennon, of the Institute of Educational Research.

[2] These numbers are averages of the two determinations made in Appendix IV.

The superiority of the younger adults is due almost entirely to their greater gain in the oral directions test. In the other three tests there was little or no difference.

Results from other experiments agree with these, in showing that the difference between age 22 and age 40 in ability to learn a logical systematic language is small, and is confined largely to the oral test. Assuming that the units of our tests correspond roughly with truly equal steps of difference in knowledge of Esperanto, ability to learn falls off about twenty per cent from age 22 to age 42, or about one part in a hundred per year.

With the aid of data furnished by the courtesy of the International Auxiliary Language Association we were able to compare the ability of adults to learn Esperanto with the ability of children of 14 to 18 and of still younger children. The facts are presented in detail in Appendix IV. Pupils 9 to 18 years old in a good private school, having over twice as much class study as the group 35 years old and over (and more than twice as much home study, if they did not shirk their assignments), gained little more than half as much. Younger groups of ages around 9 and 11 show still slower rates of gain, despite the fact that in one group they were children of exceptionally high intelligence. The facts are in flat contradiction to the doctrine that childhood is the period for easiest learning to read, write, or understand the hearing of a language, and that the early teens are the period next most advantageous. Exactitude in pronunciation was not tested in our experiments. It is probable that the superiority of adults would be somewhat less in learning a natural language, abounding in irregularities which must be mastered largely by sheer habituation. But we are convinced that the gain made in fifty or a hundred or five hundred hours of study of French or German or Italian or Spanish or Latin by a group of any age from 20 to 40 will be greater than the gain made by a group aged 8 or 10 or 12 of equal native capacity.

CHAPTER V

Learning by Adults of Inferior Intellect

All prisoners, shortly after commitment to Sing Sing Prison, are examined in the prison school. Those who show less than 7th grade ability are assigned to Standards I, II, III, IV, V, VI or VIA, and are required to attend school an hour and a quarter a day. The school is conducted by a civilian Head Teacher, but the teaching is done by prisoners. The teaching during the time of our experiments was very good. The calendar year is divided into three school terms of 16 weeks each with intervening examination periods. With the permission of Warden Lewis E. Lawes and with the cordial and intelligent cooperation of Mr. Henzel, we measured the learning of the men in this school.

TABLE 8

Adult prisoners: school registration, first term.

STANDARD	NUMBER ENROLLED
I	28
II	33
III	55
IV	87
V	26
VI	63
VIA	15
Total	307

THE TESTING PROGRAM

There were 307 men enrolled when we began, distributed in standards as shown in Table 8, above. For as many

TABLE 9

Tests used and length of intervening periods.

SUBJECT MATTER	TEST USED	STANDARDS TESTED	FORMS USED AS INITIAL TEST	FORMS USED AS INTERMEDIATE TEST	LENGTH OF FIRST PERIOD IN WEEKS	FORMS USED AS FINAL TEST	LENGTH OF WHOLE PERIOD IN WEEKS
Reading . .	Thorndike-McCall	2–6A	1 and 2	4 and 5	12	7 and 8	45
Vocabulary .	Thorndike	3–6A	A	C	12	A and B	44
Spelling . .	Trabue from Buckingham-Ayres	3–6A	1 and 2	3 and 4	8	5 and 6	35
Composition .	Nassau scale	3–6A	1 sample	1 sample	20	2 samples	48
Writing . .	Thorndike scale	1–6A	1 sample	1 sample	20	2 samples	48
Addition . .	Woody (Series B)	1 and 2	1	2	4	1 and 2	47
Subtraction .	" "	2 and 3	1	2	4	1 and 2	47
Multiplication	" "	3 and 4	1	2	4	1 and 2	47
Division . .	" "	4 and 5	1	2	4	1 and 2	47
Arith. Probs. .	Buckingham (Div. I)	3	1	2	4	1 and 2	36
" " .	" (Div. II)	5	1	2	4	1 and 2	36
" " .	" (Div. III)	6A	1	2	4	....	..
" " .	Monroe (Test I)	4	1	2	4	1 and 2	36
" " .	Monroe (Test II)	6	1	2	4	....	..

of these as we could, we secured the following data: age, whether American or foreign born, scores in two testings with the Pintner Non-Language Mental Test, and an initial, intermediate, and final test score on one or more standard educational tests. The men were tested in all subjects in which there seemed a possibility of getting measurable gains.

We have listed in Table 9 the tests used and the length of the intervening periods. The initial tests were given in the first school term of the calendar year 1926; the intermediate tests were given in the same term or very shortly after its close. The gains made between initial and intermediate tests are therefore unaffected by promotions. These gains we will speak of as first period gains. The final tests were given at the end of the third term, so that during the whole period from initial test to final test there were two promotions. We secured measurements of first-period gains for 283 men and whole-period gains for 118. The loss is entirely the result of the usual school turnover or of absence from school on testing days. No cases were discarded except for lack of scores.

An addition practice experiment was also conducted during the second term in Standard IV such as was described by Donovan and Thorndike ('13), The only differences were, that the men practiced their 4 minutes straight instead of 2 minutes at a time as the children did; and that 3 instead of 7 sheets of examples were used. The men practiced 4 minutes a day from Monday to Friday inclusive for 3 weeks. This gave measures of school learning under fairly well controlled conditions.

Differences Between Adults and Children

We compare the rate of learning of these adult men in reading, vocabulary, spelling, and the other forms of school learning by finding the number of school months

required by children to make the same amount of gain in the tests in question as made by the adults in 11 months or from the initial to the final tests. The detailed facts appear in Appendix V. The number of months required by the children varies with the test, but is on the average 9. The men made on the average 82% of the gain which children make during the same number of months of schooling. The children, however, had four times as long a school day and spent more hours on reading, writing, spelling, and arithmetic during nine school months than these adults did during eleven. Moreover, the norms stating the gains of children are for children of average intellect, while these adults were in general below average intellect. So it seems certain that these adults learned these school subjects more rapidly than they would have learned them at the age of ten or twelve.

We have checked the above comparison by combining the separate test scores for each man into a composite, giving each equal weight. The gain in composite score (average final score minus average initial score) was a very substantial one, being 9.3 times its probable error. In these composite scores, Standards III and IV so closely resemble public school grades 4 and 5 in means, variability, and overlapping that we can compare their gains with public school increases in achievement test scores. Using data from the manuals of direction for the Pintner Educational Survey Test and for the Stanford Achievement Test, we have shown in Table 10, page 51, the relation between the yearly increases and the variability of scores within the preceding grade. For grades 4 and 5, which Standards III and IV resemble, the gains are respectively .95 and .75 of the interquartile range of scores within the grade. If the men's gains are equal to the children's they should show the same relation to Standard III and IV interquartile ranges. Using ten elevenths of the men's gains to make them comparable to gains made in a ten-

month's public school year, we found the ratios to be .61 and .66.

TABLE 10

Increases in achievement test scores by grades expressed as a fractional part of the interquartile range of the corresponding grade.

GRADES	2	3	4	5	6	7
Pintner Survey Test	1.6	1.2	.8	.8	.5	.4
Stanford Achievement Test	...	1.2	1.1	.7	.7	.7
Average . . .	1.60	1.20	.95	.75	.60	.55

On the basis of this comparison the Standard III gain is 64% of the progress made by the children of grade 4 and the Standard IV gain is 88% of the year's progress made by children of grade 5. The average for Standards III and IV

TABLE 11

The results of practice in adding columns, each containing ten one-place numbers.

AMOUNT OF PRACTICE: IN MINUTES	NUMBER OF COLUMNS CORRECTLY ADDED PER MINUTE BY		
	55 adults in Standard IV	29 boys in grade 4	732 boys and girls in grade 4
0	2.2	2.7	1.6
4	2.5	2.8	
8	2.7	3.3	
12	2.8	3.6	
16	2.6	3.3	
20	2.9	3.6	
24	2.6	3.6	
28	2.7	3.6	
32	3.3	3.6	
36	3.1	3.8	
40	3.0	3.9	
44	3.4	4.0	
48	3.1	4.0	
52	3.3	4.3	
56	3.5	4.3	
60			2.3

(76%) agrees closely with the 82% obtained in the preceding comparison for the 118 men in all standards.

Table 11 (page 51) and Fig. 4 (below) show the results for the adults of Standard IV, for the fourth-grade boys measured by Donovan and Thorndike and for 732 fourth-grade children measured by Kirby ('13).

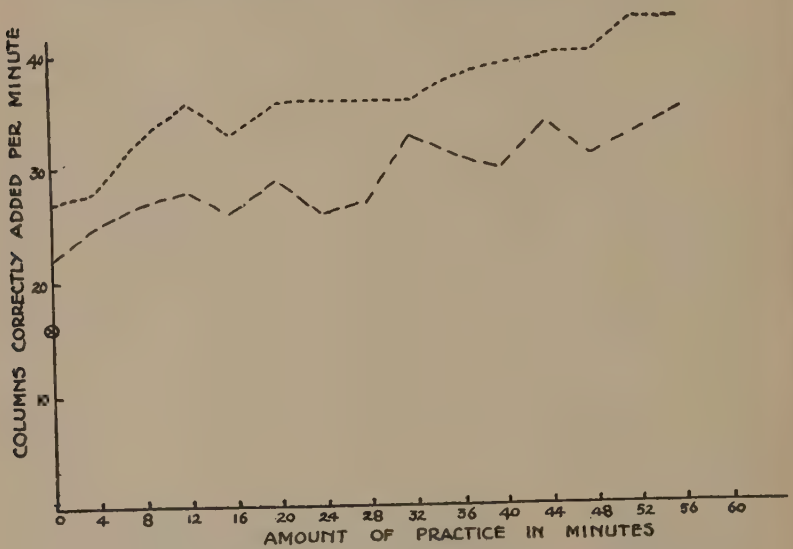


Fig. 4. Practice in Addition by 55 Adult Prisoners in Standard IV (————), 29 Boys in Grade 4, (---------) and 732 Children in Grade 4 (⊕ ⊕). The Score is the Number of Columns Added Correctly.

Kirby used the same materials, but he gave more extensive initial and final tests and distributed an hour's practice between them by four different plans, none agreeing with the one we used. In Fig. 4 we have plotted the daily scores of the 55 men and also those of the 29 boys measured by Donovan and Thorndike. For the 732 children measured by Kirby we have entered only the initial and final scores.

In 56 minutes practice the men improved from an initial score of 2.2 columns correctly added per minute to a final score of 3.5; the 29 fourth grade boys improved from 2.7 to 4.3; and in 60 minutes' practice the 732 fourth grade boys and girls improved from 1.6 to 2.3.

The comparison of gains which come from different starting points is never entirely satisfactory, but, by any reasonable consideration of the units involved, the adults gained less than one group of children and more than the other, and probably a little more than the average of the two.

Differences Between the Younger and the Older Adults

Any simple treatment is inadequate to measure the differences in ability to learn within this group of ages, 17 to 54, which are attributable to age alone. The problem requires the application of the technique of partial correlation; and our treatment of it is presented in Appendix VII. All that we shall present here is the general result and some specimens of the facts from which this result is derived.

We may best begin not with the gains made in reading, spelling, arithmetic, etc., but with a special experiment in which matters of allowing for differences in intelligence, initial ability, and foreign birth, are less complicated and less confused by differences in grade or standard.

In Standard IV, in the first term, a "substitution" learning experiment was conducted. The men transcribed a list of 420 words into numbers, the number for a letter being the numerical position of that letter in the alphabet normally arranged. This code was printed in large characters on the blackboard.[1] The men transcribed for

[1] No effort was made to determine whether age was a factor in the seating arrangement. It did not seem from observation to be a large enough factor to outweigh the advantage of being able to cover the code.

8 three-minute periods, stopping at the end of each period to count the letters transcribed. Before the 24 minute practice and after it, the men were tested in their knowledge of the code numbers. At the beginning of the period the code was uncovered, used for a sample word, and covered.

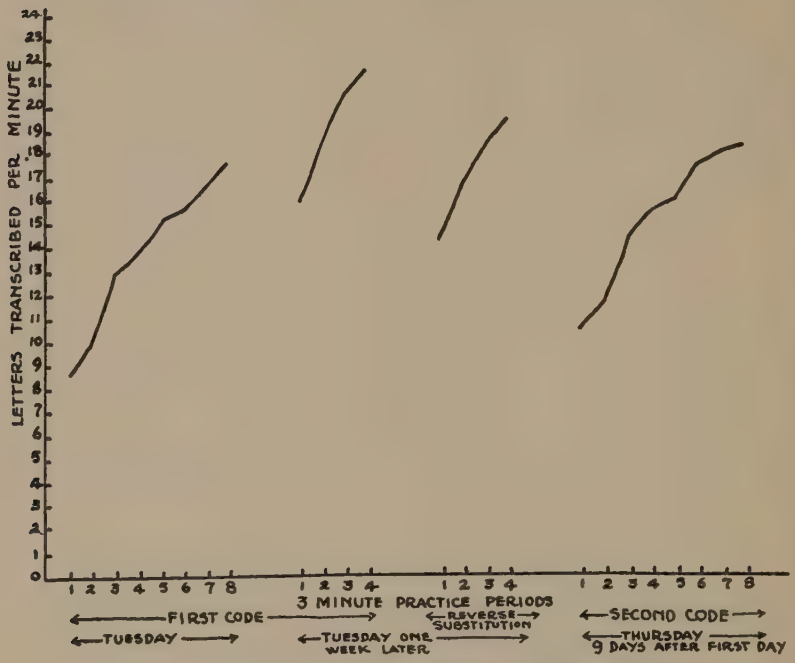


Fig. 5. Substitution Experiment: Adult Prisoners.

The letters were then dictated at the rate of one every two seconds, in the following order: *g-t-y-r-l-e-w-p-j-c-u-n-b-a-z-s-m-f-x-q-k-d-v-o-i-b.* The men had been instructed to write the letters as dictated and to record the code numbers beside as many letters as they could. These papers were collected and the test repeated. The results justified the arrangement of letters and rate of dictation. Nearly every one made a zero score. Very

few recorded as much as 1, 2 and 3 for *a*, *b* and *c*, so the initial score was taken as zero and the final test score at the end of the period (repeated for reliability) was taken as the number of code numbers learned.

One week later the same test was again given twice as a measure of retention. The men were then practiced for 4 three-minute periods in the same manner as hitherto. The scores in these four practices were used to obtain a measure of the effect of the interval upon rate and as a basis for certain measurements of transfer.

TABLE 12

Results of the substitution experiment: adult prisoners.

DAY	3 MIN. PERIOD	LETTERS TRANSCRIBED PER MINUTE			
		All $n = 54$	Age 17–24 $n = 26$	Age 25–34 $n = 18$	Age 35–54 $n = 10$
1	1	8.6	9.7	7.4	8.4
"	2	10.1	11.0	8.9	10.2
"	3	12.9	13.4	12.3	12.7
"	4	13.9	14.5	13.1	13.8
"	5	15.3	16.5	13.8	15.2
"	6	15.8	16.4	14.9	16.1
"	7	16.9	17.9	15.5	16.6
"	8	17.8	18.7	16.6	17.8
8	1	15.8	17.0	13.5	16.3
"	2	18.6	19.7	16.4	19.9
"	3	20.6	21.4	18.7	22.4
"	4	21.9	22.6	19.9	23.4
"	1	14.3	15.1	13.0	14.3
"	2	16.7	17.7	15.0	17.0
"	3	18.3	18.7	16.9	19.7
"	4	19.7	20.4	17.2	19.7
10	1	10.5	12.3	9.1	8.4
"	2	11.9	13.3	10.2	11.1
"	3	14.3	15.5	12.4	14.5
"	4	15.6	16.4	14.2	16.1
"	5	16.1	16.8	15.0	16.0
"	6	17.5	18.3	16.9	16.4
"	7	18.2	19.1	16.6	18.6
"	8	18.5	19.0	18.0	18.1

This twelve-minute review practice was followed by 12 minutes of practice in the reverse substitution, transcription of numbers into letters, using the same code. Two days later the men practiced for 8 three-minute periods, transcribing letters into numbers as at first, but using a code changed to confuse. The letters were placed on the board in columns instead of rows and their numbers were their numerical positions from the end of the alphabet normally arranged. The average results of the entire substitution experiment are plotted in Figure 5, page 54, and recorded in Table 12.

There is here a very substantial gain; and the differences of older from younger adults in gain may be determined with considerable precision. The average gains in rate of substitution from period 1 to period 8 for the men of ages 17 to 24, 25 to 34, and 35 to 54, respectively, are 9.0, 9.2, and 9.4.

The oldest group in this experiment differed from the youngest in being less intelligent as measured by the Pintner Non-Language Mental Test, and in starting from a lower initial ability in the substitution. The averages were:

	Under 25	25–34	35 and Over
Average Pintner score	325	258	234
Average first period score in substitution	9.7	7.4	8.4

By the partial correlation technique it is possible to infer what the results would have been if we had performed the experiment with men of the ages of ours but all of equal ability in the Pintner test and equal ability at the beginning of the substitution. The change would have been slight.

The gains in the addition practice experiment for the different age groups were as follows:

	Under 25	25–34	35–39
American born: average age	22	29	38
average gain	6.2	3.6	5.0
Foreign born: average age	22	29	42
average gain	3.8	5.6	4.6
Average gain American and foreign born	5.0	4.6	4.8

The average gains in the school learning measured during the first period for the three age groups were 1.5, 1.4, and 1.4. The average gains during the whole period in the groups for which we computed such gains were 6.0, 6.5, and 4.9 for the three age groups.

The gains in relation to age are summarized in Table 13, page 58. Considering the number of individuals concerned (with some consideration of the length of the experiments), we may assign weights to the four experiments of Table 13, in the proportions of 1, 1, 5, and 4. By this the gains for the three age groups are in the proportions, 100, 99, and 90. Considering not only number of individuals and length of the experiment but also control of conditions and reliability of the determinations we may assign equal weights to the four experiments. This puts the gains in the proportions 100, 99, and 94.

If the American and foreign born of the addition practice are combined as individuals, and if equal weights are given to the substitution, the addition, the first-period school learning and the total-period school learning, the final results are 100, 97, and 91, for the three age groups respectively. By any reasonable weighting they will be very near to 100, 98, and 90. The men at 41 learn nearly as well as the men at 21.

In general the older prisoners are low in Pintner scores and in initial ability at the thing to be learned. In attitude

TABLE 13

The gains made by adult prisoners of ages 17 to 24, 25 to 34, and 35 to 54

	Number of Persons			Average Age			Average Gain			Gains as Per cents of the Gain at 17–24	
	17–24	25–34	35 up	17–24	25–34	35 up	17–24	25–34	35 up	25–34	35–54
I. Rate of substitution .	26	18	10	22	29	40	9.0	9.2	9.4	102	104
II. Addition practice . .	18	21	12	22	29	40	5.0	4.6	4.8	92	96
III. School learning: first period	109	103	71	21	29	41	1.5	1.4	1.4	93	93
IV. School learning: whole period	35	45	38	21	29	41	6.0	6.5	4.9	108	82
Weighted average for all four groups				21	29	41				99	90
Unweighted average . .				$21\frac{1}{2}$	29	$40\frac{1}{2}$				99	94

toward their school work as judged by their teachers they are superior to the younger prisoners.

When allowance is made for these facts, when the cases of experiments III and IV of Table 13 are treated separately by standards, and when the records are more fully utilized by the calculation of correlation coefficients between age, gain, Pintner score, initial score in the thing learned, and attitude toward school work, the general fact still holds. The drop in learning ability in twenty years from 21 to 41 in this group due to age alone is about one-half of one per cent per year.

The substitution experiment was so planned as to furnish data on the relation of age to retention, and on the relation of age to the transfer of improvement from one ability to a second which is helped or hindered by the first. The detailed results appear in Appendix VIII. The older men retained what they learned a little better than the younger. They were equally able to make use of an ability that transfers *positively* to help them with a second ability. They were less able than the younger men to prevent or overcome hindrance by an ability that transfers *negatively*.

On the whole, the results with these adult men of low level of intellect support the conclusions that the curve of ability to learn in relation to age from 22 to 42 is a very slow decline and is no greater for inferior intelligence than for superior.

CHAPTER VI

The Learning of High School Subjects by Adults in Public Evening High Schools

We measured the intelligence and the gains in certain school subjects in the case of 886 pupils in two large evening high schools who were taking one or more of the following subjects: algebra, biology, civics, English (first-year), French, German, Latin, and Spanish. The initial and final measurements from which the gains were computed were taken in one school on Oct. 28, 1926 and Jan. 13, 1927; and in the other school on Nov. 8, 1926 and Jan. 11, 1927.

The tests used and the times allowed were as follows:

Algebra—	Initial—	Columbia Research Bureau (mimeographed, abridged); Part I, 30 min., Part II, 10 min.	Form B
	Final—	Columbia Research Bureau (mimeographed, abridged); Part I, 30 min., Part II, 10 min.	Form A
Biology—	Initial—	Ruch-Cossman, as in the Manual	Form A
	Final—	Ruch-Cossman, as in the Manual	Form B
Civics—	Initial—	Brown-Woody, as in the Manual	Form A
	Final—	Brown-Woody, as in the Manual (mimeographed).....	Form B
English—	Initial—	Part III, Tests 1-5, of The Thorndike Intelligence Examination for High School Graduates, 36 min.....	Form R
	Final—	Part III, Tests 1-5, of The Thorndike Intelligence Examination for High School Graduates, 36 min.....	Form T

French—	Initial—	Columbia Research Bureau; Part I, 25 min., Part II, 15 min.....	Form A
	Final—	Columbia Research Bureau; Part I, 25 min., Part II, 15 min.....	Form B
German—	Initial—	Columbia Research Bureau; Part I, 25 min., Part II, 15 min.....	Form A
	Final—	Columbia Research Bureau; Part I, 25 min., Part II, 15 min.....	Form B
Latin—	Initial—	White, as in the Manual.....	Form A
	Final—	White, as in the Manual.....	Form B
Spanish—	Initial—	Columbia Research Bureau; Part I, 25 min., Part II, 15 min.....	Form A
	Final—	Columbia Research Bureau; Part I, 25 min., Part II, 15 min.....	Form B

The intelligence examination (*CAVD*) was taken on Oct. 21, 1926, in the first school and on Nov. 4, 1926 in the second school. Age was recorded from the pupils' statements. Attendance from Sept. 6, 1926 to Jan. 31, 1927 was recorded from the official school records. Amount of home study was reported by the pupils. (These records of home study are not complete.) Colored pupils were noted by the examiners. Foreign-born pupils who had difficulty with English were noted. The gain made by each individual in each subject of study was expressed as a deviation from the average gain for that subject in that school and then was divided by the variability (median deviation, or Q) of the gains for that subject in that school. For example: Mr. *AB* gained 2 in the French test; the median gain in French in his school was 5, and the variability was 6. His gain in French is then computed as $\frac{5-2}{6}$ or $-.5$. If an individual had gains recorded in two or more subjects, these were averaged, so that for each individual we have one measure representing all that we know about the gain made by him.

By this treatment any one subject is given as much weight as any other subject, in cases where an individual

took two or more subjects, and any one person is given as much weight as any other person, in determining the average gains for certain age and school groups.

These were:

14, 15, and 16 year-olds—whites in School *N*
17, 18, and 19 year-olds—whites in School *N*
20 to 24 year-olds— whites in School *N*
25 to 29 year-olds— whites in School *N*
30 and over 30 year-olds—whites in School *N*

14, 15, and 16 year-olds—colored in School *N*
17, 18, and 19 year-olds—colored in School *N*
20 to 24 year-olds— colored in School *N*
25 to 29 year-olds— colored in School *N*
30 and over 30 year-olds—colored in School *N*

14, 15, and 16 year-olds—in School *E* with no language handicap
17, 18, and 19 year-olds—in School *E*, with no language handicap
20 to 24 year-olds— in School *E*, with no language handicap
25 to 29 year-olds— in School *E*, with no language handicap
30 and over 30 year-olds—in School *E*, with no language handicap

14, 15, and 16 year-olds—in School *E*, with some language handicap
17, 18, and 19 year-olds—in School *E*, with some language handicap
20 to 24 year-olds— in School *E*, with some language handicap
25 to 29 year-olds— in School *E*, with some language handicap
30 and over 30 year-olds—in School *E*, with some language handicap

The reliability of any one of the measures of gain then depends partly upon how many subjects are comprised in it. When it is from only one subject, its reliability depends upon the reliability of the test instrument, and

is so low as to make treatment by partial correlation inadvisable. We shall, therefore, in the main, deal only with the averages of groups which may have fairly high reliability because of the numbers of individuals involved and whose reliability can in all cases be determined. Unfortunately, the number of individuals in the older age groups is very small. These evening high schools are attended chiefly by pupils of high-school and college age. Consequently, in spite of the large numbers tested, the information about ages over 24 is scant and not of high reliability. Table 14, below, shows the average gain for each of the groups. Ages 20 to 24 have, on the whole, the highest gains. Ages 14 to 16 have the lowest.

In combining the facts for the different groups it is necessary to allow for the different numbers of cases involved. For example, in comparing age 20 to 24 with age 30 or over, we have a superiority for the young of .90 in I with 38 and 6 individuals involved; a superiority of .68 in II, with 17 and 1 individuals involved; an inferiority of .85 in III, with 40 and 3 individuals involved; and an inferiority of .14 in IV with 19 and 7 individuals involved. It would obviously be unwise to attach as

TABLE 14

The average gains in tests of algebra, biology, etc., made by certain groups of pupils in evening high schools.

	14–16 YRS.		17–19 YRS.		20–24 YRS.		25–29 YRS.		30 YRS. OR OVER	
	Av. Gain	No.	Av. Gain	No.	Av. Gain	No.	Av. Gain	No.	Av. Gain	No.
I. School *N*, white	−.42	21	+.02	56	+.53	38	+.04	13	−.37	6
II. School *E*, no handicap	−.31	55	+.32	59	+.08	17	+1.20	1	−.60	1
III. School *E*, language handicap	−.26	36	+.01	98	+.02	40	−.14	7	+.87	3
IV. School *N*, colored	−.30	1	−.39	13	−.27	19	−.33	9	−.13	7

much weight to the .68 as to the .90, or to the − .85 as to the − .14, or to the .68 as to the − .85.

We shall, therefore, combine differences in gain only after weighting each in proportion to the size of the smaller of the two groups involved. Thus we obtain the weighted average superiority in gain of age 17 to 19 over age 14 to 16 as follows:

$$\frac{(21 \times .44)+(55 \times .63)+(36 \times .27)+(1 \times -.09)}{21 + 55 + 36 + 1}$$

This gives .33. The differences and the weighted average differences so obtained are shown in Table 15, below.

TABLE 15

Differences between average gains in tests of algebra, biology, etc., made by certain groups of pupils in evening high schools.

	17 to 19—14 to 16	20 to 24—14 to 16	20 to 24—17 to 19	25 to 29—14 to 16	25 to 29—17 to 19	25 to 29—20 to 24	30 or Over—14 to 16	30 or Over—17 to 19	30 or Over—20 to 24	30 or Over—25 to 29
I. *N*, white	.44	.95	.51	.46	.02	−.49	.05	−.39	−.90	− .41
II. *E*, no handicap	.63	.39	−.24	1.51	.88	1.02	−.29	−.92	−.68	−1.80
III. *E*, handicap	.27	.28	.01	.12	−.15	−.16	1.13	.86	.85	1.01
IV. *N*, colored	−.09	.03	.12	−.03	.06	−.06	.17	.26	.14	.20
Weighted average difference	.33	.49	.15	.38	.02	−.23	.33	.07	−.15	.01

The pupils of age 30 or over gain decidedly more than those of age 14 to 16, a little more than those of age 17 to 19, the same as those of age 25 to 29, and less than those of age 20 to 24. Unfortunately, there are only seventeen in the group aged 30 or over.

It is possible, by making certain fairly justifiable assumptions, to work back from these differences to an estimate of the gains for different age groups for individuals freed from the influences of color, school and language difficulty, and in terms of the units of the actual test scores. The way this is done is described in Appendix IX. The final result of the computations is that these estimated gains are in the proportions of:

57 for age 14–16
84 for age 17–19
100 for age 20–24
86 for age 25–29
87 for age 30 or over

We have now to discover how far the age groups are different in intelligence score, attendance, and reported home study. The facts appear in Tables 16, 17, 18, and 19.

The 30 and over group scores highest in intelligence *CAVD*. The 20 to 24 group is next. The 14 to 16 and 17 to 19 groups are low and closely alike. The 25 to 29 group is still lower. The weighted differences are as shown in Table 17. We must then consider methods of allowing for these differences.

The 30 and over group was the highest in respect of attendance. They attended 8½ days more than the lowest group (14 to 16), or about 10% more. Roughly, the attendance was 77, 79, 79, 82, and 86 days for the groups in order of age. We may need to allow for this.

The record of the hours of study per week per subject is, as stated previously, a transcript of the pupils' statements. Such statements are full of errors, but these will not do harm to our inferences concerning age differences unless there is a difference between the young and the old in the amount of exaggeration of the amount of home study. Whether there is, or not, we do not know, and have no means of finding out. Taken at its face value, Table 19 shows a notably greater amount of home study for the old than for the young. The hours per week per subject are,

roughly, 2.4, 2.7, 3.0, 3.3 and 4.4 for the five age groups in order. We may need to allow for this.

TABLE 16

The average scores in *CAVD* intelligence made by certain groups of pupils in evening high schools.

	14–16 Yrs.		17–19 Yrs.		20–24 Yrs.		25–29 Yrs.		30 Yrs. or Over	
	Av. Score	No.	Av. Score	No.	Av. Score	No.	Av. Score	No.	Av. Score	No.
I. *N*, white .	380	20	387	50	388	33	374	12	408	6
II. *E*, no handicap	376	55	380	57	393	16	403	1	365	1
III. *E*, language handicap	374	36	368	98	389	40	360	7	372	2
IV. *N*, colored	383	1	372	13	375	19	373	10	383	7

TABLE 17

Differences between average *CAVD* intelligence scores made by certain groups of pupils in evening high schools.

	17 to 19—14 to 16	20 to 24—14 to 16	20 to 24—17 to 19	25 to 29—14 to 16	25 to 29—17 to 19	25 to 29—20 to 24	30 or Over—14 to 16	30 or Over—17 to 19	30 or Over—20 to 24	30 or Over—25 to 29
I. *N*, white .	7	8	1	−6	−13	−14	28	21	20	34
II. *E*, no handicap	4	17	13	27	23	10	−11	−15	−28	−38
III. *E*, handicap .	− 6	15	21	−14	− 8	−29	− 2	4	−17	12
IV. *N*, colored .	−11	−8	3	−10	1	− 2	0	11	8	10
Weighted average differences . .	1	13	10	− 7	−9	−13	15	12	7	16

TABLE 18

The average number of days attendance (of a possible 96) for certain groups of pupils in evening high schools.

	14–16 YRS.		17–19 YRS.		20–24 YRS.		25–29 YRS.		30 YRS. OR OVER	
	Days Att.	No.	Days Att.	No.	Days Att.	No.	Days Att.	No.	Days Att.	No.
I. *N*, white .	82	16	82	43	81	32	85	8	86	4
II. *E*, no handicap	76	52	80	54	78	16	84	1	86	1
III. *E*, handicap	76	34	78	97	79	40	82	7	80	1
IV. *N*, colored	73	1	82	12	80	15	81	9	88	6

TABLE 19

Average number of hours of home study per week per subject as reported by certain groups of evening high school pupils.

	14–16 YRS.		17–19 YRS.		20–24 YRS.		25–29 YRS.		30 YRS. OR OVER	
	Av. Hrs.	No.	Av. Hrs.	No.	Av. Hrs.	No.	Av. Hrs.	No.	Av. Hrs.	No.
I. *N*, white .	2.4	21	2.7	49	3.2	35	3.4	12	5.3	4
II. *E*, no handicap	2.5	53	2.7	45	2.6	12	0.0	1	0.0	1
III. *E*, handicap	2.0	32	2.6	86	3.1	29	4.4	7	4.5	2
IV. *N*, colored	10.0	1	2.8	9	2.8	15	2.9	12	4.3	6

We can estimate how much allowance, if any, is needed by finding out the relations between gain and *CAVD* score, attendance, and home study, and the interrelations of the three latter.

This we have done, using the 229 white individuals for whom complete records are available, and who had measures of gain in at least two studies. The facts in detail are presented in Tables 22 to 30, at the end of this chapter, and are summarized in Tables 20 and 21. In Table 20, page 69, we report measurements of the difference in gain between the upper and lower halves in *CAVD* score, between the upper and lower halves in attendance, and between the upper and lower halves in amount of home study reported. By Table 20, one unit more of *CAVD* score is accompanied by .006 unit more of gain; one day more of attendance is accompanied by .006 unit more of gain; one hour more of home study per week per subject is accompanied by .041 unit less gain. These estimated allowances are all small and the net result of applying them to the facts of Table 15, page 64, is very slight. For example, the difference of .33 for group 17 to 19 minus group 14 to 16 would be changed to .32 (by subtracting $1 \times .006$ and $2 \times .006$ and $.3 \times -.041$).

The difference of .49 for group 20 to 24 minus group 14 to 16 would be changed to .42 (by subtracting $13 \times .006$ and $2 \times .006$ and $.6 \times -.041$). The difference of .15 for group 20 to 24 minus group 17 to 19 would be changed to .10 (by subtracting $10 \times .006$ and $0 \times .006$ and $.3 \times -.041$). The difference of .38 for group 25 to 29 minus group 14 to 16 would be changed to .41 (by subtracting $-7 \times .006$ and $5 \times .006$ and $.9 \times -.041$). The other differences of Table 15 (.02, $-.23$, .33, .07, $-.15$, and .01) would be changed to .08, $-.15$, .27, .03, $-.18$, and $-.06$, respectively.

TABLE 20 *

Estimates of the amount of allowance for differences in *CAVD* score, attendance, and home study derived from the amount of gain in tests on school subjects made by the upper and lower halves in *CAVD*, attendance, and reported amount of home study.

	A	B	C	D
	School *N* $n = 59$	School *E* no handicap $n = 61$	School *E* language handicap $n = 109$	Weighted average, using $\frac{A+B+2C}{4}$
Average *CAVD* score of lower half in *CAVD*	370	363	349	
" " " upper " " "	397	387	373	
" Gain " " lower " " "	−.24	−.27	−.69	
" Gain " " upper " " "	+.19	−.24	−.61	
Difference in *CAVD* score	27	24	24	
" " Gain	.43	.03	.08	
" " " accompanying 1 *CAVD*	.016	.0012	.0033	.006
Average attendance of lower half in attendance	76	65	71	
Average attendance of upper half in attendance	89	84	87	
Average gain of lower half in attendance	−.02	−.45	−.08	
" " " upper " " "	−.05	−.06	−.03	
Difference in attendance	13	19	16	
" " Gain	−.03	.39	.05	
" " " accompanying 1 day	−.0023	.0205	.0031	.006
Average home study for lower half in home study	1.5	1.2	1.4	
Average home study for upper half in home study	4.3	3.8	4.0	
Average gain for lower half in home study	−.032	−.26	+.076	
" " " upper " " " "	.000	−.25	−.133	
Difference in home study	2.8	2.6	2.6	
" " gain	−.032	+.01	−.206	
" " " accompanying 1 hour of reported home study	−.011	.004	−.079	−.041

* The reader may be disturbed by the fact that the individuals who reported the larger amounts of home study are the ones who gained less than the others. This does not, of course, mean that, if any individual had studied longer, he would have gained less. For our purposes we need not seek an explanation of the fact, since what we wish to accomplish is to allow the difference as it presents itself in the records. It may be a chance result of the nature of the groups measured, or a consequence of a tendency on the part of unsuccessful learners to spend or to report excess study time, or both to spend and to report it in excess.

Working back from these differences, as shown in Appendix IX, the estimated gains are in the proportions of

59 for age 14 to 16 yrs.
85 " 17 to 19 yrs.
100 " 20 to 24 yrs.
89 " 25 to 29 yrs.
87 " 30 yrs. or over

These differ from the uncorrected results of page 65 (57, 84, 100, 86, and 87) only very slightly.

What we have done crudely by obtaining the facts of Table 20 could be done more elegantly by computing the regressions from their partial correlations: (*a*) of gain with *CAVD* score, attendance and home study being equalized, (*b*) of gain with attendance, *CAVD* score and home study being equalized, and (*c*) of gain with home study, *CAVD* score and attendance being equalized. These partial correlations can be computed from the "total" correlations of Table 21. It is obvious that the

TABLE 21

The correlations of *CAVD* score, attendance, and amount of home study reported with gain, and their intercorrelations.

	School *N* $n = 59$	School *E* no handicap $n = 61$	School *E* language handicap $n = 109$	Average	
				equal weight	weights 1, 1, and 2
CAVD score with gain . .	+.31	+.03	−.07	+.09	+.05
Attendance " " . .	−.18	+.31	+.14	+.09	+.10
Home study " " . .	−.03	−.08	−.29	−.13	−.17
CAVD score with attendance	−.24	+.08	+.11	−.02	+.02
CAVD score " home study	−.08	−.03	−.05	−.05	−.05
Attendance with home study	−.08	+.12	+.04	+.03	+.03

results corrected by this method will differ very slightly, if at all, from the uncorrected results, since the intercorrelations of *CAVD* score, attendance, and home study

are all approximately zero, and the correlations of gain with them are very low and average approximately zero. So this method also would leave the 57, 84, 100, 86, and 87 of page 70 substantially unchanged. The cruder method seems preferable because of the asymmetry of the distributions for age. attendance and home study.

TABLE 22

The relation of *CAVD* score and gain: school *N*.

CAVD ↓	Gain → −											−		+							+	All
	3.2	2.9	2.6	2.3	2.0	1.7	1.4	1.1	.8	.5	.2	0	.2	.5	.8	1.1	1.4	1.7	2.0	2.3	2.6	
333–340																1						1
341–348		1												1	1							3
349–356																						
357–364									1	2	1											4
365–372								1		1	3			1								6
373–380				1				3		2	5	4		2				1				18
381–388											1	3	1	2								7
389–396						1					1		2	1		1	2					8
397–404						1			1		1	1	3			1					1	9
405–412									1		2				1	1						5
413–420								1														1
421–428														1								1
All		1		1		2		5	3	5	14	8	6	8	2	4	2	1			1	63

TABLE 23

The relation of *CAVD* score and gain: school *E*, no handicap.

CAVD ↓	Gain → −										−		+							+	All
	3.2	2.9	2.6	2.3	2.0	1.7	1.4	1.1	.8	.5	.2	0	.2	.5	.8	1.1	1.4	1.7	2.0	2.3	2.6	
341–348							1															1
349–356						1		1		2	1	2										7
357–364									1	1		1		1	1							5
365–372							1	1	1	2	4		1	1	2				1			14
373–380							1		1	1	4	3	1	1	1		1					14
381–388								1	1	1				2								5
389–396							2	1	1	1	1		1			1		1				9
397–404							1	1		1												3
405–412									1			1			1							3
All						1	6	5	6	9	10	7	3	5	5	1	1	1	1			61

TABLE 24

The relation of *CAVD* score and gain: school *E*, language handicap.

CAVD ↓	Gain → −										−		+							+	All
	3.2	2.9	2.6	2.3	2.0	1.7	1.4	1.1	.8	.5	.2	0	.2	.5	.8	1.1	1.4	1.7	2.0	2.3	2.6	
317–324										1												1
325–332																						
333–340	1					1						1	1			1	1					6
341–348							1		1	2	4	1	1	2	1							13
349–356											2	4	2	3	2	1						14
357–364						1	1	1	2	2	1	4	3	1	1	1						18
365–372					1		3	1		3	3	3	4	2	2	1	1					24
373–380							1	1	2	1	2	2		3	2	1			1			16
381–388							1			1	3	2	1		1							9
389–396											2		1	1	2							6
397–404												1										1
405–412														1								1
All	1				1	2	7	3	5	10	17	18	13	13	11	5	2		1			109

TABLE 25

The relation of attendance and gain: school *N*.

Days Attendance ↓	Gain → −										−		+							+	All
	3.2	2.9	2.6	2.3	2.0	1.7	1.4	1.1	.8	.5	.2	0	.2	.5	.8	1.1	1.4	1.7	2.0	2.3	2.6	
60–63																						
64–67										1	1	1	1									4
68–71								1					1									2
72–75														1		1					1	3
76–79											2		1	1		1		1				6
80–83						2			1		2	3	1	3								12
84–87				1				2	1		2	2		1			1					10
88–91		1						1		3	2	1	1	1	2	1	2					15
92–95									1		2	1	2									6
All		1		1		2		4	3	4	11	8	7	7	2	3	3	1			1	58

TABLE 26

The relation of attendance and gain: school *E*, no handicap.

DAYS ATTENDANCE ↓	GAIN → −										−		+							+	ALL
	3.2	2.9	2.6	2.3	2.0	1.7	1.4	1.1	.8	.5	.2	0	.2	.5	.8	1.1	1.4	1.7	2.0	2.3	2.6	
20–23										1												1
24–27																						
28–31																						
32–35																						
36–39																						
40–43																						
44–47														1								1
48–51										1	1											2
52–55										1												1
56–59							1	1														2
60–63																						
64–67									1		2											3
68–71							1	1			3	1	2									8
72–75						1	2	1	1	1	1	1		1	1							10
76–79								1	1	1				2				1				6
80–83							1			1		1			1							4
84–87							1		1	2	1	3		1	3							12
88–91								1	2		2	1	1			1	1					9
All						1	6	5	6	8	10	7	3	5	5	1	1	1				59

TABLE 27

The relation of attendance and gain: school *E*, language handicap.

DAYS ATTENDANCE ↓	GAIN → −									−		+									ALL
	3.2	2.9	2.6	2.3	2.0	1.7	1.4	1.1	.8	.5	.2	0	.2	.5	.8	1.1	1.4	1.7	2.0	2.3	2.6	
44–47											1											1
48–51																						
52–55								1														1
56–59																						
60–63									1	2		1			1							5
64–67										2	2	2		1								7
68–71							2		1	1	1	2	1		1		1					10
72–75							1	1		1	2	4	3	3	1	2	1					19
76–79					1		2			1	2		1	5	1							13
80–83	1					2	1		2	1	1	1	2	1	1	1						14
84–87							1		1	1		3	3	1	1	1						12
88–91								1		1	8	5	3	2	5	1			1			27
All	1				1	2	7	3	5	10	17	18	13	13	11	5	2		1			109

TABLE 28

The relation of reported home study and gain: school *N*.

HALF-HOURS OF HOME STUDY ↓	GAIN → −										−		+							+	ALL
	3.2	2.9	2.6	2.3	2.0	1.7	1.4	1.1	.8	.5	.2	0	.2	.5	.8	1.1	1.4	1.7	2.0	2.3	2.6	
0													1									1
1						1					1											2
2								1			2			1		1						5
3								2		1	1		1	1			1					7
4									2		2	2	1	5	1							13
5		1						1		1	1	2				1						7
6													1	1		1					1	4
7											1		1									2
8				1						1		1	1									4
9																						
10											1	3					1	1				6
11						1				1	1		1									4
12											1						1					2
13																						
14																						
15																						
16									1													1
17																						
18																						
19																						
20															1							1
All		1		1		2		4	3	4	11	8	7	8	2	3	3	1			1	59

TABLE 29

The relation of reported home study and gain: school *E*, no handicap.

HALF-HOURS OF HOME STUDY ↓	GAIN → −									−		+							+	ALL
	3.2	2.9	2.6	2.3	2.0	1.7	1.4	1.1	.8	.5	.2	0	.2	.5	.8	1.1	1.4	1.7	2.0	2.3	2.6	
0								1		2					1							4
1												1	1		1							3
2						1	1		2	2	2	1										9
3												1		2								3
4							1			2	4		2	1	1							11
5								1	2		2	1			1		1					8
6							2	2	1	1	1	1			1	1						10
7									1		1							1				3
8														1								1
9								1				1										2
10							1					1		1								3
11							1															1
12										1												1
13																						
14																						
15																						
16										1												1
17																						
18																						
19																						
20																			1			1
All						1	6	5	6	9	10	7	3	5	5	1	1	1	1			61

TABLE 30

The relation of reported home study and gain: school *E*, language handicap.

HALF-HOURS OF HOME STUDY ↓	GAIN → −										−		+							+	ALL
	3.2	2.9	2.6	2.3	2.0	1.7	1.4	1.1	.8	.5	.2	0	.2	.5	.8	1.1	1.4	1.7	2.0	2.3	2.6	
0							3				1	1	1	1	1							8
1										1		1										2
2										3	1	1	3	1	4							13
3										1	1	1	1	1	1							6
4					1	1			2	1	4	2	4	4	3	2	1		1			26
5						1	1			1	1	1	1			1						7
6	1						1	1		2	3	5	2	1	1		1					18
7									1		1			2								4
8							2	2	1	1	1	3	1	1								12
9														1		1						2
10									1		2	2										5
11											1											1
12														1								1
13																						
14															1	1						2
15																						
16																						
17																						
18																						
19																						
20												1										1
21																						
22																						
23																						
24											1											1
All	1				1	2	7	3	5	10	17	18	13	13	11	5	2		1			109

CHAPTER VII

Learning by Adults in Secretarial Schools

We have devoted a great deal of time to studies of the learning of typewriting and shorthand. The results are valuable, but not nearly so valuable as we had hoped. They are valuable for two reasons. The learning is a genuine sample of professional and trade learning. It was carried on under ordinary conditions in secretarial schools frequented by adults. The amount of progress can be measured objectively and with adequate precision. They are less valuable than we had hoped because the number of individuals over twenty-five is very scant, even in the schools which have the largest proportion of adult students.

The nature of the tests used and the conditions of their administration are described in Appendix XI.

All the tests were given by the same person (Dr. Woodyard). All scoring was done by experts (Parrish Little and A. Grove Day) using the same keys and rules concerning errors. Each learner reported the amount of time given to the study of typewriting and of shorthand up to the time of the first test, and between that and later tests. We have as a result for each individual learner the following measures:

1. age at the time of the first test
2. intelligence (the score in *Army Alpha*)
3. ability in typing in the first test, number of lines minus .1 line per error
4. reported number of hours spent on typing up to the first test
5. ability in typing in the last test, number of lines minus .1 line per error
6. reported number of hours spent on typing between the first test and the last
7. total reported hours spent on typing (4 plus 6)

8. gain in typing score (5 minus 3)
9. ability to write shorthand symbols for words and phrases in the first test (the number correct out of 150 in a modified *Hoke test*)
10. reported number of hours spent on shorthand up to the first test
11. ability to write shorthand symbols for words and phrases in the last test (the number correct out of 150 in a modified *Hoke test*)
12. reported number of hours spent on shorthand between the first test and the last
13. total reported hours spent on shorthand (10 plus 12)
14. gain in shorthand score (11 minus 9)

The scores attained in 9 and 11 were without any pressure for speed and represent the intellectual control of the symbols, not skill in making them during dictation. The time spent was recorded, however, so that we have:

15. the rate at the first test
16. the rate at the last test
17. the gain in rate, all in words per hundred seconds

We have records from seven classes, representing three schools in 1926–1927 and three schools in 1925–1926. In three of these seven classes the first and last tests were far apart, representing an interval of about 200 hours of study of typing and about 400 hours of study of stenography. In the other four the interval was much shorter.

The total reported times from the beginning of the study of typing and shorthand to the last test averaged approximately as follows for the seven classes.

	Typing	Shorthand
C.	250	500
G.C.	270	300
G.N.C.	290	310
U.S.	100	90
P.	165	160
M.	145	120
G.	190	165

We have compared five age groups, 15 to 16, 17 to 19, 20 to 24, 25 to 29, and 30 or over. The comparison is complicated, because these age groups have differences in intellect and in time reported as spent upon the learning for which allowance must be made and because it is best to treat each class by itself, since the distribution of ages as well as the time spent in study differs by classes. The details of the comparison are presented in Appendix XI. The end result is that ages 17 to 19 and 20 to 24 are indistinguishable, and that the two older age groups on the whole learn almost as well as those 17 to 24 or younger. The group aged 15 to 16 do as well as those 17 to 24 of equal intellect. There is no demonstrable difference between learning typewriting and learning shorthand, in the age effect.

For the sake of the reader who does not wish to canvass the details of fact and method of Appendix XI, but does wish to have a general idea of the evidence, we present a very much simplified treatment of it here.

Typewriting

We use the last test score in connection with the reported total hours of study as the measure of amount of learning. Classes *C*, *G C*, and *G N C* differed little in average intelligence scores (141, 149, and 144) or in the total time reported as devoted to typewriting. So we may combine their last scores and total-hours measures as if they formed one big class. Classes *M* and *P* also differed little in average intelligence scores (115 and 120) or in average total hours. So we combine their last scores and total-hours measures as if they formed one class. Class *G* and Class *U S* are kept as units. The results are as shown in the columns 1 and 2 of Table 31. In columns 3 and 4 of Table 31 these results are expressed as per cents of the last score or total hours for ages 17 to 19 of the class

in question. This age is taken as a base because it has the largest population and so the greatest reliability. The general fact is that the older ages made lower scores but studied fewer hours.

TABLE 31

The relation of age to ability to learn typewriting.

	AGE	N	1 Average last score	2 Average total hours	3 Per cent which 'last score' is of 'last score' for age 17 to 19	4 Per cent which 'total hours' is of 'total hours' for age 17 to 19
Class $C+GC+GNC$	15 to 16	2	155	296	101	106
	17 to 19	84	154	279	100	100
	20 to 24	57	151	264	98	95
	25 to 29	6	132	282	86	101
	30 or over	2	145	253	94	91
Class $M+P$	15 to 16	23	103	139	93	83
	17 to 19	24	111	167	100	100
	20 to 24	6	92	180	83	108
	25 to 29					
	30 or over	1	74	72	67	43
Class G	17 to 19	46	170	217	100	100
	20 to 24	28	162	168	95	77
	25 to 29	5	163	146	96	67
	30 or over	1	153	126	90	58
Class US	17 to 19	19	112	118	100	100
	20 to 24	5	88	76	79	64
	25 to 29	1	64	65	57	55
Weighted averages in proportion to N						
15 to 16					94	85
17 to 19					100	100
20 to 24					95	89
25 to 29					88	82
30 or over					86	71

We allow for differences in total hours

.4 of a point of typing score per hour from hour 60 to hour 100
.3 of a point of typing score per hour from hour 100 to hour 150
.2 of a point of typing score per hour from hour 150 to hour 300

and thereby obtain the estimates of Table 32, below. These allowances are required to be equitable only within any one class group. Their approximate validity is shown by evidence presented in Appendix XI.

TABLE 32

Estimated last-test scores in typewriting, if the last test had been taken after 279 hours in class $C + GC + GNC$, after 139 hours in class $M + P$, after 168 hours in class G, and after 118 hours in class US

	CLASS $C + GC + GNC$	CLASS $M + P$	CLASS G	CLASS US
15 to 16	153	103	...	...
17 to 19	154	104	160	112
20 to 24	154	83	162	103
25 to 29	131	...	168	83
30 or over	150	95	164	...

The 15 to 16 group are one per cent lower than the 17 to 19 group. The 20 to 24 group are equal to the 17 to 19 group in the comparison based on 57 cases, 21 per cent lower in the comparison based on 6 cases, 2 per cent higher in the comparison based on 28 cases, and 8 per cent lower in the comparison based on 5 cases. Attaching weights in the proportions of 57, 6, 28, and 5 to these determinations, we have as a result a weighted average inferiority of the 20 to 24 group to the 17 to 19 group of 1 per cent.

The 25 to 29 group is 15 per cent lower than the 17 to 19 in the comparison involving 6 cases, 5 per cent higher in the comparison involving 5 cases, and 26 per cent lower in the comparison involving 1 case. Attaching weights in the

proportions of 6, 5, and 1, we have a weighted average inferiority of 8 per cent.

The 30 or over group is 3 per cent lower than age 17 to 19 in the comparison involving 2 cases, 9 per cent lower in one comparison involving 1 case, and 3 per cent higher in one comparison involving 1 case. Its weighted average inferiority to age 17 to 19 is then 3 per cent, so far as these scant data go.

In Appendix XI it is shown that no corrections for differences in *Alpha* score are required in the case of learning to typewrite.

Shorthand

In the case of the shorthand last scores we report here (in Table 33, page 83) the comparisons with age 17 to 19 chosen as the base because it has the largest populations and so the most reliable averages) in the form of per cents, together with the per cents which the reported time was of the reported time for age 17 to 19. Age 20 to 24 shows 98 per cent as high score as age 17 to 19, from 99 per cent as much time. Age 25 to 29 shows 100 per cent as high score as age 17 to 19 from 97 per cent as much time. Age 30 or over shows 87 per cent as high score from 73 per cent as much time. By any reasonable allowance for time, it will be not far below age 17 to 19. These results will be altered slightly by correction for differences in *Alpha* score which will lower the 20 to 24 score by about 1 per cent and raise the 30 or over score by about 1 per cent.

Age 15 to 16 will have its comparative status raised by correction for the inferiority of its individuals in *Alpha* score. With that and with any reasonable allowance for the shorter time, it will be very close to age 17 to 19 and 20 to 24.

TABLE 33

The relation of age to ability to learn shorthand.

	CLASS	n	PER CENT WHICH THE LAST SCORE IS OF THE LAST SCORE FOR Age 17–19	PER CENT WHICH THE TOTAL HOURS IS OF THE TOTAL HOURS FOR Age 17–19
Age 15–16 . . .	C	2	111	113
	M	13	82	81
	P	10	104	87
	Weighted average		93	86
Age 20–24 . . .	C	14	105	98
	G C	23	104	116
	G N C	20	101	101
	U S	5	97	100
	M	5	92	94
	P	1	94	26
	G	28	89	87
	Weighted average		98	99
Age 25–29 . . .	G C	6	95	117
	U S	1	114	98
	G	5	104	72
	Weighted average		100	97
Age 30 or over . .	C	1	107	87
	G C	1	103	116
	M	1	45	22
	G	1	92	64
	Weighted average		87	73

CHAPTER VIII

Corroborative Experiments

In general we have not compared age groups in respect of learning unless we could measure intellect, initial ability, and time devoted to study, so as to allow for differences in these. In the present chapter we shall be less rigorous, and report three sets of facts about adult learning which lack one or more of these accessory measurements.

The first set concerns an experiment in associative learning with graduate students at Teachers College, Columbia University, in which the time devoted to study is controlled and is alike for all, and something approximating the initial ability is measured. Intellect is not; but the investigations of Dr. Spence give correlations of age with score in a test of intellect for Teachers College M.A. candidates in general[1] as follows:

400 students in the summer session of 1925, .041
362 students in the regular session of 1926, .014
300 students in the summer session of 1926, .158

The average is .04. This is so low that it may be disregarded.

Two hundred seventy-seven graduate students of education participated in this experiment in learning to transcribe a series of disconnected words[2] in terms of the following code alphabet:

[1] The ages will be in the main from 25 up.

[2] For convenience, one list was used for the first seven work periods and a second list for the eighth work period.

For:	*a*	*b*	*c*	*d*	*e*	*f*	*g*	*h*	*i*	*j*	*k*	*l*	*m*
Write:	*g*	*t*	*y*	*r*	*l*	*j*	*w*	*p*	*v*	*c*	*u*	*n*	*h*

For:	*n*	*o*	*p*	*q*	*r*	*s*	*t*	*u*	*v*	*w*	*x*	*y*	*z*
Write:	*a*	*z*	*s*	*m*	*f*	*x*	*q*	*k*	*d*	*e*	*o*	*i*	*b*

The experiment was done with six different groups, but under uniform conditions. There were eight work periods, each of three minutes, with intervals of 80 sec., 70 sec., 60 sec., 55 sec., 50 sec., 45 sec., and 45 sec., which were spent by the subjects in counting and recording the number of letters transcribed in the previous work period or in resting according to the following instructions: "At the end of every three-minute period, mark your place on the word list, and on the cross-section paper, draw a circle around the last letter you wrote. Count the number of letters you have transcribed and record your score in the place provided on the code sheet. There are 32 small blocks in a line and 4 small blocks in a large block. That will help you to count your letters. I think time enough is allowed for counting, but if you're not through counting when I tell you to get ready for another work period, there's no harm done; just stop counting and get ready."

The number of letters transcribed in each of the eight work periods was carefully checked by Dr. Tilton, and also the number of errors for the first and for the eighth period. The number of errors was only about one per cent of the number of letters written.

We have the following results for 28 individuals of age 20 to 24, 139 individuals of age 25 to 34, and 104 individuals of age 35 or over.

	Age 20–24	Age 25–34	Age 35 and Over
Number	28	139	104
Average age	23	29	41
A. Average number of letters correctly transcribed in the first three minutes	59.8	56.0	47.3
B. Average gain from first to last work period in number of letters correctly written	28.0	27.9	22.8
Unreliabilities of the averages of B. (*P.E.*'s)	± 1.2	± .7	± .7
C. Average number of letters correctly transcribed in the last three minutes	87.8	83.9	70.1
Unreliabilities of the averages of C. (*P.E.*'s)	± 2.6	± 1.1	± 1.3

The averages of line *A* are the result, first, of the quickness and precision of the individual in perceiving the words, remembering their letters, finding these in the code, observing the code equivalent, writing it, keeping his place, and so on, and second, of some actual learning during the first period. The averages of line *B* are the result of learning with some disturbances from excitement, boredom, and other factors, and with some of the very early learning not counted in. The averages of line *C* are, of course, due to the sum of the forces producing *A* and *B*.

On the whole the 28.0, 27.9, and 22.8 are the safest indicators of learning. They do not include the earliest steps of the learning, and are in so far imperfect. If we could assume that all the ages started with the same ability, that that ability was zero, and that nothing but learning produced the scores, we could use 87.8, 83.9, and 70.1 as the measures of total learning for the three groups and separate each into an early and later learning (59.8

and 28.0, 56.0 and 27.9, and 47.3 and 22.8 respectively). But the first assumption is dubious, and the second is certainly wrong. If a person understood the instructions and remembered them, but learned nothing from his experiences after the instructions were given and he

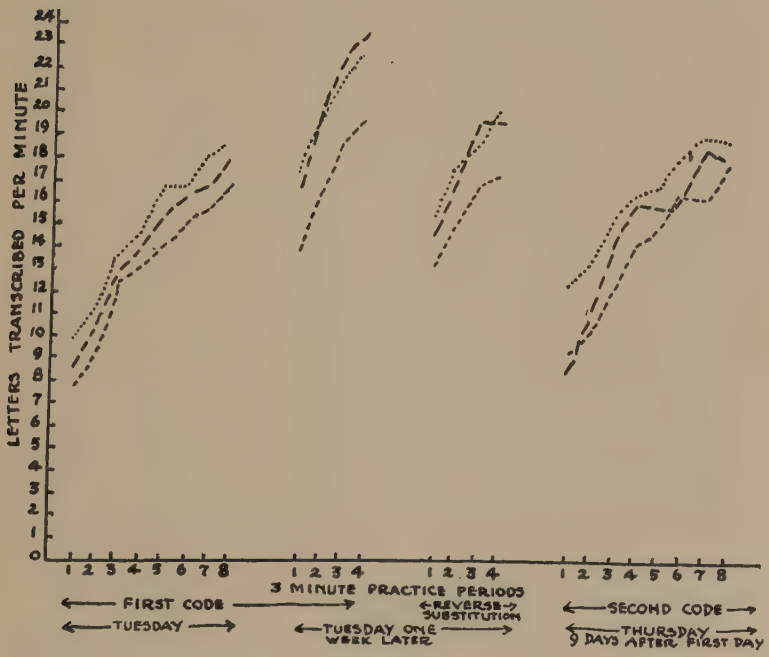


FIG. 6. SUBSTITUTION EXPERIMENT: RESULTS FOR AGES 17 TO 24 (DOTS), 25 TO 34 (SHORT DASHES), AND 35 TO 54 (LONG DASHES).

began work, he could still make a substantial score. An individual may, in fact, make no gain from Period I to Period VIII (and so probably none within Period I) and still have a substantial score. The oldest group may be estimated then to have gained about 15 per cent less than the others. The difference is about five times its probable error. Table 34 presents the gains in detail.

TABLE 34

Frequencies of gains in number of letters transcribed, period I to period VIII.

GAIN	FREQUENCY AT AGE								
	20–24	25–29	30–34	35–39	40–44	45–49	50–54	55–59	60–64
−8 to −5				1					
−4 " −1									
0 " 3			1	2			1		
4 " 7		1	3	2		2			1
8 " 11	2	4	3	2	3	1	1	1	
12 " 15	2	5	8	5	2	1	1		
16 " 19	1	4	4	6	4	2			
20 " 23	5	14	7	9	4	2			
24 " 27	4	11	10	9	3	1	3		
28 " 31	4	8	7	10	4	5			
32 " 35	3	6	9	3				1	
36 " 39	4	6	4	2	1				
40 " 43	2	6	4	2	2	1			
44 " 47		3	1	2					
48 " 51	1	2		1					
52 " 55		4		1					
56 " 59		1	1						
60 " 63									
64 " 67		1	1						

As a check on this result we have records from 21 individuals who continued the experiment for eight additional practice periods at a date from three to nine days later. The facts for them were as follows:

	AGE 20–24	AGE 25–34	AGE 35 OR OVER
Number	4	8	9
Average age	24	28	44
Average number right in period 8	81.3	97.4	69.8
" " " " 9	75.0	90.4	65.1
" " " " " 16	101.5	114.0	82.1
Gain, period 8 to 16	20.2	16.6	12.3
" " 9 " 16	26.5	23.6	17.0

Hollingworth ('27, p. 310) reports the results of a very brief period of learning to transcribe by a key in the form of the total score. This score is a compound of the initial ability and the gain made. The subjects were 534 adults ranging in age from a little below twenty to forty-five years of age. The average score was 68 for those below 20, 64 for those 20 to 24, 60 for those 25 to 29, 58 for those 30 to 34, and 57 for those 35 or over. The five age groups were practically alike in four tests of intelligence (completing sentences, naming opposites, word building, and immediate memory for digits), the oldest group scoring a trifle higher than the others.

The second set of facts concerns an experiment in learning to connect twenty-five three-place numbers each with a three-letter nonsense syllable, as a result of the visual presentation of twenty-five pairs like: vel 148, zen 183, vem 136, for two seconds each, eighteen times, the order of presentation being different each time. Immediately after the eighteenth presentation, the subjects wrote on a sheet containing the twenty-five syllables, the number they thought belonged to each. Four days later the same was done with a second set of twenty-five pairs, the only difference in procedure being that the subjects were advised in the test to write first all the numbers they were sure of and then fill in the others.[1]

The results for the different age groups are as follows:

Age group	18–24	25–34	35–54
Number of cases	76	42	32
Average age	21	29	43
Average Form I Score	9.5	6.9	6.2
Average Form II Score	12.9	11.3	7.8
Average Total Score	21.9	18.2	14.0
P. E. Average Total Score	± .9	± 1.0	± .9

[1] A fuller description of the experiment is given in Appendix XI.

The differences in average total scores are:

Between youngest and middle group.....3.7 ± 1.3 (P.E.)
Between middle and oldest group.....4.2 ± 1.3 (P.E.)
Between youngest and oldest group.....7.9 ± 1.3 (P.E.)

The score obtained by the group of average age 43 is 64 per cent of that obtained by the group aged 18 to 24.

No direct measures of the differences in intelligence of the three groups were obtained, but the following indirect evidence was obtained that these differences did not cause the differences in learning. The only important probable cause of selection for intellect in relation to age in the total group is the inclusion of about 50 regular college students among the younger ones. If these are not used in the calculation, the superiority of the younger group in learning remains unimpaired. (r for age with learning scores is $-$ .26 with them in and also $-$ .26 with them out.) The grades obtained by 43 of the subjects in a class in educational psychology containing a fair representation of all the ages were higher for the old than for the young, averaging 16.8 for those 18 to 24, 18.6 for those 25 to 34, and 20.1 for those 35 or over. For these 43 subjects the corresponding average learning scores were 26.2, 20.9, and 14.8.

Dr. Tilton, who conducted these experiments, is confident that there was no less interest or effort in the learning of the numbers on the part of the older individuals.

The third set of facts concerns the grades received by graduate students at Teachers College.

If young and old students are equal at the start, and if they spend equal times in study, the average grades they receive are, in so far as they are impartial measures of achievement in the courses, measures of ability to learn. We do not know that these particular young and old groups were alike in intellect, but we know that in general

the old in Teachers College are closely the same as the young. We do not know the initial status of young and old relative to the knowledge and skill in the particular subjects studied. Presumably, in the long run the young will be a little less competent than the old at the start in the practical subjects, and about equally competent in the theoretical subjects. We do not know what the age differences are in the amount of time spent on studies by M. A. candidates at Teachers College.

On the whole, the older ages probably have the advantage in intellect, preparation for the courses taken, and time spent in study, but this advantage can hardly be very great.

Dr. Spence found correlations of age with average grade received as follows: For 100 M.A. candidates, using the grades in one summer session, — .133. For 200 M.A. candidates, using the grades received in one half-year, .054. Weighting these as 1 and 2 we have a weighted average of — .01.

We have checked this result by taking the entire list of grades for each of 465 M.A. candidates (mostly individuals other than those studied by Dr. Spence), selecting all the June candidates for years '23 to '26 inclusive, in four groups, according to the diplomas for which they were candidates, as follows:

I. Teacher or supervisor of English.
II. Supervisor of kindergarten and primary grades,
Principal or supervisor of primary schools,
Principal of elementary schools,
Supervisor of elementary schools,
Supervisor of upper elementary schools, and
Critic teacher in elementary schools.
III. Principal of junior high schools, and
Principal of high schools.
IV. Superintendent of schools.

Within each of these four groups the individuals, young and old, are more or less comparable as to general aims,

education, and experience; and study much the same subjects.

We tabulate all the grades for all the persons of age 20 to 24, 25 to 29, 30 to 34, etc. in each of these groups, and determine the average number of $A+$'s, A's, $A-$'s, of $B+$'s, etc. per person in each age division in each group. We then find the median grade for each age division of each group, counting an *Incomplete* as lower than average grade, and counting grades of *Passed* as if they were distributed pro rata from $A+$ to F, and counting H ("attendance only") in each of these two ways. We

TABLE 35

The distribution of grades for the average student of age 20–24, 25–29, etc., among those taking diplomas as teachers or supervisors of English.

AGES	20–24	25–29	30–34	35–39	40–44	45–49	50 OR OVER
Number of individuals . .	38	42	38	34	10	9	5
Average frequency of $A+$		.05	.24			.22	
" " " A	1.66	3.00	4.16	5.67	5.60	4.00	1.00
" " " $A-$	1.37	1.86	2.62	2.18	3.60	2.11	1.00
Average frequency of $B+$	3.02	3.00	3.56	3.82	4.80	4.22	2.60
" " " B	8.00	9.76	8.15	10.20	6.80	10.88	6.80
" " " $B-$	2.24	2.71	2.58	1.85	2.10	2.33	2.60
Average frequency of $C+$	2.21	2.40	2.08	1.56	3.60	1.66	4.80
" " " C	3.42	6.22	3.50	4.00	2.50	3.00	7.40
" " " $C-$	.71	1.02	.60	.35		.22	1.60
Average frequency of $D+$		.05					.80
" " " D	.24	.05	.26	.29			.40
" " " $D-$							
Average frequency of F	.08	.07		.09			
Average frequency of *Inc.*	.13	.21		.53			
Average frequency of H	1.18	.93	1.03	1.15	.30	.88	
Average frequency of P	7.15	8.47	9.57	7.29	5.40	9.22	9.80
Average number of points taken	31.42	39.84	38.37	39.00	34.70	38.77	38.80
Median, calling an H a low record	.23	.20	.53	.59	.90	.61	low
Median, calling an H the same as a P	.32	.25	.60	.75	.93	.65	low

call the difference from the top of *B* to the bottom of *B*, unity, and use the bottom of the *B*'s as a zero point.

The results appear in Tables 35, 36, 37, 38, and 39. The essential final result is that the older ages do a little better. Ages 20 to 29, 30 to 39, and 40 to 49 have grades of .32, .32, and .41 respectively. After 50 there is a drop, but the number of cases is scant at these late ages, so that the exact amount of the drop is not certain. The number of

TABLE 36

The distribution of grades for the average student of age 20–24, 25–29, etc., among those taking diplomas as supervisor of kindergarten and primary grades, principal or supervisor of primary schools, principal of elementary schools, supervisor of elementary schools, or critic teacher in elementary schools.

AGE	20–24	25–29	30–34	35–39	40–44	45–49	50 OR MORE
Number of individuals . .	7	30	43	34	30	9	5
Average frequency of *A*+		.10	.16	.53	.17		
" " " *A*	2.43	6.27	6.10	7.64	7.43	6.78	5.00
" " " *A*−	.86	3.18	2.60	2.87	3.10	2.33	3.71
Average frequency of *B*+	4.29	6.43	4.44	3.62	4.77	4.89	1.57
" " " *B*	16.86	15.03	15.79	13.98	13.52	17.22	10.86
" " " *B*−	4.86	4.47	5.72	3.56	4.62	5.78	4.14
Average frequency of *C*+	9.14	6.63	5.29	4.12	4.33	4.22	4.57
" " " *C*	13.14	6.62	8.79	7.76	6.80	6.89	9.57
" " " *C*−	3.14	1.23	1.12	1.71	.67	.44	1.71
Average frequency of *D*+			.05	.06			
" " " *D*	1.43	.10	.67	.29	.87		.43
" " " *D*−							
Average frequency of *F*	.29		.05		.10		
Average frequency of *Inc.*			.09	.32	.37	.33	.43
Average frequency of *NR*			.09	.03			
Average frequency of *H*	.43	.27	.49	.53	.50	.33	.86
Average frequency of *P*		.20	.33	.09	.63	1.22	
Average number of points taken	56.86	50.53	51.77	47.12	47.87	50.44	42.86
Median, calling an *H* a low record	below 0	.39	.23	.37	.40	.38	below 0
Median, calling an *H* the same as a *P*	below 0	.40	.23	.39	.42	.39	.01

points and the median grade by age divisions, allowing equal weight to each of the four groups, are as shown in Table 39, page 95.

TABLE 37

The distribution of grades for the average student of age 20–24, 25–29, etc., among those taking diplomas as principals of junior high schools, or principals of high schools.

AGE	20–24	25–29	30–34	35–39	40–44	45–49	50 OR OVER
Number of individuals . .	2	18	21	6	9	1	0
Average frequency of *A*+					.22		
" " " *A*	3.00	3.78	4.57	3.00	6.89		
" " " *A*−	1.00	.50	1.24	.67	2.22	2.00	
Average frequency of *B*+	5.00	2.11	2.86	2.33	3.44	7.00	
" " " *B*	13.00	10.17	11.62	10.67	12.67	13.00	
" " " *B*−		2.44	2.05	3.83	3.44	6.00	
Average frequency of *C*+	5.00	4.78	4.38	5.67	3.55		
" " " *C*	5.00	9.06	8.62	10.17	5.67	6.00	
" " " *C*−		1.50	.86	1.33	1.33		
Average frequency of *D*+		.11	.14				
" " " *D*	1.00	.33	.24	.83			
" " " *D*−							
Average frequency of *F*		.22	.24				
Average frequency of *Inc*		.11					
Average frequency of *H*		.17		.50	.22		
Average frequency of *P*		.44	.10	.83	.33		
Average number of points taken	33.00	35.72	36.90	39.83	40.00	34.00	
Median, calling an *H* a low record	.42	low	.16	low	.45	.39	
Median, calling an *H* the same as a *P*	.42	low	.16	low	.44	.38	

TABLE 38

The distribution of grades for the average student of age 20–24, 25–29, etc., among those taking diplomas as superintendent of schools.

AGE	20–24	25–29	30–34	35–39	40–44	45–49	50 OR OVER
Number of individuals . .	1	14	30	15	8	3	3
Average frequency of *A*+		.43	.20	.20			
" " " *A*	3.00	5.50	5.73	11.20	6.12		1.00
" " " *A*−	6.00	2.14	1.37	.73	3.25		
Average frequency of *B*+	6.00	3.79	1.63	2.87	3.12	2.00	1.33
" " " *B*	5.00	11.71	11.97	10.27	12.88	12.33	2.67
" " " *B*−	7.00	4.07	2.73	3.00	2.88	2.00	5.00
Average frequency of *C*+	2.00	4.79	4.20	3.33	2.62	4.67	3.67
" " " *C*	3.00	6.07	7.73	7.47	9.50	21.00	11.33
" " " *C*−		.93	.83	.67	1.38		8.67
Average frequency of *D*+			.70				
" " " *D*		.29		.20			
" " " *D*−							
Average frequency of *F*			.10				
Average frequency of *Inc*			.30		.50	.67	
Average frequency of *H*		.14	.33	.27	.25	.67	
Average frequency of *P*		2.00	.17	1.87	.75		
Average number of points taken	32.00	41.86	38.00	42.07	43.25	43.33	33.67
Median, calling an *H* a low record	.80	.31	.16	.50	.32	low	low
Median, calling an *H* the same as a *P*	.80	.32	.18	.52	.33	low	low

TABLE 39

Summary of Tables 35 to 38.

AGE	AVERAGE NUMBER OF POINTS TAKEN	MEDIAN OF MEDIAN GRADES	
		CALLING *H* EQUAL TO *P*	CALLING *H* LOWER THAN THE MEDIAN
20–24	38	.37	.33
25–29	42	.28	.26
30–34	41	.21	.20
35–39	42	.45	.43
40–44	41	.43	.42
45–49	42	.39	.38
50 or over	38	Near the low end of B	Near the low end of B−

CHAPTER IX

Age Differences in Sheer Modifiability

It is obvious that in some sorts of learning a person may be aided greatly by abilities already acquired. So training in algebra facilitates the learning of calculus, and training in the grammar of one Indo-European language facilitates the learning of the grammar of a second. In our experiments, previous training in English, Latin, French, or German may have facilitated the learning of Esperanto, and training in writing with the right hand may have facilitated the learning of wrong-hand writing. If the amount of previous training in such a case is correlated with age, the comparison of different ages in respect of ability to learn may measure the effect of amount of previous training rather than any absolutely essential feature of age. It will measure a compounding of the influence of age in and of itself, and of the training which, in the persons in question, went with age; and the two may act in opposite directions.

So it is well to seek some sort of learning which is very little subject to facilitation by training, and use the results of experiments with it, as aids in interpreting the results obtained in the case of wrong-hand writing, Esperanto, school studies, typewriting, and shorthand.

We have therefore compared twelve individuals 20 to 24 years old, averaging 22, with twelve individuals 35 years old or older, averaging almost 42, in motor learning of a very, very simple sort, which is the best representative we have been able to devise of sheer modifiability or plasticity, little influenced by the fund of ideas and habits

which the individual starts with, and little controlled by methods of learning. This learning consists in the acquisition of the power to respond to four signals by four acts. The signals are *Draw 3 inches*, *Draw 4 inches*, *Draw 5 inches*, and *Draw 6 inches*. The acts are shoving a pencil point in one quick jerk to approximately the correct distance, starting from a straight edge, with the eyes closed. From the beginning to the end of the learning the learner sees no line that he draws, and knows nothing about its length save that it is right or wrong. "Right" means within $\frac{1}{8}$ inch of the correct length for the 3-inch line, and within $\frac{1}{4}$ inch in the case of the others. "Wrong" means more than $\frac{1}{8}$ (or $\frac{1}{4}$) inch from the correct length.

The arrangements in detail were as follows: The subject was seated, blindfolded, at a table with a drawing board, along the left-hand edge of which a thin strip of wood about two inches wide had been fastened in such a way that a large sheet of cross-section paper (16 × 21 inches) could be slipped between it and the board and held fastened to the board. The right-hand edge of this strip served as a fixed starting edge for all lines. The cross-section paper was so ruled that the experimenter could tell quickly and surely whether any line drawn was "right" or "wrong."

The subject first drew 600 lines without any statement of right or wrong. Then on each of seven days (successive except for Sundays and an occasional necessary absence) he drew 600 lines, receiving the information "right" or "wrong" after each. Finally a few days later he drew 600 with no statement of "right" or "wrong." The experimenter gave the signals "Draw 3-inch lines," "Draw 4-inch lines," etc. according to a prearranged order, which was alike for every series of 600, and was made up of 150 of each length in sequences of from 4 to 8, mixed at random.

Learning to draw with eyes closed a line of stated length

requires very fine adjustments comparable to those involved in the correct pronunciation of words or the higher degrees of skill in games or crafts. At the start one's attempts are far from correct and very variable, but it is possible to attain a high degree of precision and uniformity. For example, *Wa*, after 4500 trials of each length with announcement of "right" or "wrong," drew 600 lines to be 3 in., 4 in., 5 in., 6 in., in a random order with no announcement of "right" or "wrong" or other aid, with an average error of .11 in. for the 3 in., .13 in. for the 4 in., .18 in. for the 5 in., and .15 in. for the 6 in. lines. Before training her average errors were .82 in., .93 in., 1.27 in., and .98 in. respectively. *M* after 4200 trials of each length, reduced her original errors from .38 in., .54 in., .72 in., and 1.13 in. to .08 in., .09 in., .11 in., and .11 in. respectively. *Rob* by similar training reduced her errors from .32 in., .40 in., .84 in., and 1.09 in., to .09 in., .14 in., .15 in., and .17 in. respectively.

The essential facts for each individual are reported in Appendix XII. We shall report only the final averages here.

In score in a test of intellect (*CAVD*) the young were a little inferior. The averages were 412 and 419.

In the series of 600 before any training by the announcement of "right" and "wrong," the young and the old were nearly indistinguishable in ability. The divergences from the right responses were as follows:

	Age 20–24	Age 35 or Over	Difference in Favor of the Young
3″	.74 in.	.77 in.	+.03 in.
4″	1.00 in.	.91 in.	−.09 in.
5″	1.21 in.	1.15 in.	−.06 in.
6″	1.39 in.	1.33 in.	+.06 in.
Average			−.015 in.

The average per cent of the lines drawn which would have been called "right" was 11.4 for the young and 15.0 for the old. (The variation is, however, so great in both groups that this is no proof of initial superiority of the old.) From the very first training period, the young take the lead and maintain it throughout. In the last of the seven training periods they have 59 per cent right to 49 per cent for the old. In the test without any announcements of "right" or "wrong" they drop to 30, and the old drop to 21, as shown in Fig. 7, page 100. The average divergences from the correct responses in the test after the training were as follows:

	Age 20–24 Yrs.	Age 35 Yrs. or Over	Difference in Favor of the Young
3″	.35	.47	.12
4″	.44	.63	.19
5″	.56	.73	.17
6″	.67	.87	.20
Average			.17

The reductions in the errors as a result of the training were as follows:

	Age 20–24 Yrs.	Age 35 Yrs. or Over	Per Cent Which Gain of the Old Is of Gain of the Young
3″	.39 in.	.30 in.	77
4″	.56 in.	.28 in.	50
5″	.65 in.	.42 in.	65
6″	.72 in.	.46 in.	64
Average			64

This superiority of the young is corroborated by an earlier experiment with three individuals 47, 47, and 51

years old and six college undergraduates 17 to 21 years old, which is reported in Appendix XIII.

Learning to draw lengths to order with eyes closed is a case of learning or connection forming where the situations (draw 3 inches — draw 4 inches — draw 5 inches — draw 6 inches) are perfectly identifiable and

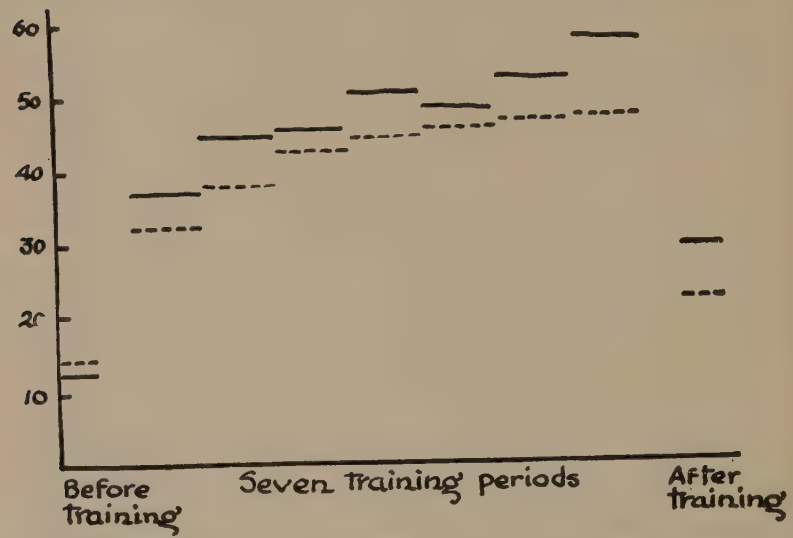


FIG. 7. THE COURSE OF IMPROVEMENT IN DRAWING LENGTHS WITH EYES CLOSED IN ADULTS 20–24 (CONTINUOUS LINE) AND 35 OR OVER (DOTTED LINE): THE PER CENT OF CORRECT RESPONSES.

at the learner's command, the task being to identify and control certain responses and connect these with the four situations.

It would be desirable to compare young and old also in learning equally simple tasks, devoid of influence by ideas and methods due to past training, but of a second and third type. The second is learning where the responses are perfectly identifiable and at the learner's command, the task being to identify the situations and connect the

responses with them, as when a series of a hundred groups ranging from white to black are presented in random order and the learner is required to name them — 1 (for white), 2, 3, 4....to 100 (for black). The third type is learning where both the situations and the responses are entirely identifiable and at the learner's command, the task being simply to connect them, as when a hundred nonsense syllables are to be connected with the numbers 1 to 100.

We made a beginning with experiments of the second type, but they were so very expensive in the time required of experimenter and subjects that we thought it better to drop them in favor of experiments which provided more practical information containing the learning of actual total subjects, such as algebra, biology, civics, and languages.

We have made one experiment of the third type. In order to diminish the effect of differences in zeal and in the use of devices to make the connections plausible, interesting, and free from confusion, we concealed the experiment within another,[1] in the following manner: The learner transcribes words, using a visible code such as:

for	*a b c d e f g*	etc.
write	*g t y r l j w*	etc.

He is lead to try to transcribe as many as possible. Nothing is said about learning the code. On the contrary special care is taken that he devote himself to attaining a maximum of letters written.

At the end of the main experiment each individual was tested as to his knowledge of the code, being required to write the letters of the alphabet with its code equivalent under each.

[1] The first experiment in transcribing words described in the previous chapter.

The results were as follows:

	20–24 Yrs.	25–34 Yrs.	35 Yrs. and Over
Number of Individuals	28	139	104
Average Number of Elements of the Code Learned	10.4	8.3	6.3
Unreliability (P. E.)	±.7	±.3	±.3

There is here again a clear difference against the oldest group; and the middle group as to age is here a mid group as to amount learned and remembered.

In connection with these figures, it should be remembered that the older group transcribed only 80% as many letters and so had only 80% as many repetitions to learn. They remembered 61% as much of the code per minute of time spent, and about 77% as much per repetition of the connection. In so far as the older individuals spent their excess time per repetition in thinking *a is g, b is t, c is y,* etc., time should be the basis of comparison for our present purposes. In so far as they spent their excess time in slower finding of the symbols and more waste time, repetitions should be the basis. The latter is probably nearer the truth.

We have no security in comparing these differences in gain in drawing lines and learning a code with the differences found in gain in other abilities, such as Esperanto or high-school subjects. For example, we do not know whether the difference between gains of 31.5 and 24.7 in the Esperanto score is less or more than the difference between reductions of .56 in. and .28 in., in the error in drawing four-inch lines. The percentile comparisons which we have reported for convenience are perhaps as reliable as any that could be now devised. Using them, the difference between age 42 or thereabouts and age 22 or

thereabouts is clearly greater in the learning chosen to represent an approach to sheer modifiability than in the abilities representing the general run of learning. The facts are summarized in Table 40, below. Drawing lines and learning the code show per cents of 64 and 61, as compared with a median of 88 for the eleven other deter-

TABLE 40

Summary of the relation of age to ability to learn according to the group and ability concerned.

U = the university group, including students at the Carolina College for Women.
P = the prisoners.
H = the evening high-school students.
S = the students in secretarial schools.

GROUP	ABILITY	GAIN IN SCORE			PER CENT WHICH *O* IS OF *Y*
		Y		*O*	
		20–24	25–34	35 or over	
U	Drawing lines				64
	Wrong-hand writing	57	51	41	72
	Substitution (transcribing words)	28.0	27.9	22.8	81
	Learning code	10.4	8.3	6.3	61
	Esperanto	31.5	26.3	24.7	79
	Learning numbers to fit nonsense syllables	21.9	18.2	14.0	64
	University studies			?	over 100
P	Substitution (1, 2, 3, etc., for *a*, *b*, *c*, etc.)	9.0	9.2	9.4	104
	Elementary school studies	100	100	88	88
	Addition practice	5.0	4.6	4.8	96
H	Algebra, Civics, English, etc.				87 for 30 or over
S	Typewriting				*
	Learning stenographic symbols				†

* Approx. 95 for 30 or over.

† Approx. 100 for 30 or over.

minations. It also is the case that the inequalities in the units of the different scores are, so far as we can estimate them, such that reduction to true scales would probably accentuate the greater difference in gain for the sheer modifiability sort of learning. A reduction in the error of drawing lines from .75 in. to .65 in. is probably not so great a gain as a reduction from .65 in. to .55 in., and that again is probably not so great a gain as a reduction from .55 in. to .45 in., and so on. When young and old begin nearly alike, as at .74 in. and .77 in. and drop to .35 in., and .47 in., our statement of the gains as .39 in. and .30 in. or 77% of .39 in., gives probably a higher per cent than would be had from a comparison in truly equal units of a scale running from a true zero point. In the case of learning the code also, the letters first learned have a probability of being those which for some reason are easier to learn, if there are any such.

The facts of Table 40 in general are fairly consistent with the hypothesis that the old are considerably inferior to those around 22 in a general basic modifiability but compensate for this inferiority somehow (probably by better appreciation and organization and use of what is learned, possibly by greater interest) when learning typewriting or stenography or school studies. Thus in wrong-hand writing, which would presumably be itself not a bad sample of sheer modifiability, the per cent is low (72). In memorizing numbers to fit nonsense syllables from repeated short exposures the per cent is low (64). In school studies the per cents are high.

On the other hand this hypothesis would lead us to expect low per cents for typewriting and the learning of stenographic symbols, which have large components of skill and brute memory, and a high per cent for Esperanto; but the opposite is found.

It is also the case that there are other plausible explanations of the greater inferiority of the old in gain in certain

abilities than in others than the explanation by greater inferiority in abilities more representative of sheer modifiability. For example, there is reason to believe that the older individuals are in general more self-conscious, and more so in the experiments with novel tasks than in the regular learning of schools. Or it may be argued that the older subjects, especially among the university groups, are less ready and willing than the young to learn nonsense codes, drawing lines, and other such useless matters, and so, in spite of honest effort and a desire to score well, do not really apply themselves as whole-heartedly. Or it may be argued that the evidence for greater inferiority of the old in abilities representing sheer modifiability is all from within the college and university group, and that that group shows much greater inferiority of the old in all abilities than do the prisoners or the secretarial school students or the evening high-school students.

The last suggestion seems to us specially important. The old-young percentage for Esperanto with the university group is 79. This is much lower than any found in the other groups, though learning Esperanto is presumably much farther removed from sheer modifiability than stenography, typewriting, and most of the prisoners' learning. If we disregard the two abilities specifically chosen to approximate sheer modifiability, the old-young percentages for the university and college group are 64, 72, 79, 81, and 100 (the last being from grades in courses). The per cents for the other groups are 87, 88, approximately 95, 96, high, approximately 100, and 104, with a median at about 95. The difference between the groups is thus as great as the difference between drawing lines and Esperanto within the same group. Except for the university and college group, the evidence is rather against the hypothesis, since the old-young per cent is lower for school studies than for typewriting and learning stenographic symbols.

These considerations may prevent too careless a comparison of the results of the line-drawing and the code-learning at their face value with the other results listed in Table 40. On the whole, it seems reasonable to state the case concerning sheer modifiability as follows:

The general tendency from all our experiments is for an inferiority of about 15 per cent as a result of 20 years from twenty-two on. Learning representing an approximation to sheer modifiability unaided by past learning shows considerably more inferiority than this. Actual learning of such things as adults commonly have to learn shows considerably less.

CHAPTER X

Testimony Concerning Adult Learning

The facts reported in Chapters II to IX make it certain that adults can learn rather easily and rapidly, and probably could learn much more than they do. Since they are not prevented from learning by inability, we may profitably inquire what does prevent them. As one means of answering this question, we have secured the testimony of thirty-nine persons 40 years old or older, of forty-three persons from 30 to 39 years old, and of seventeen persons 20 to 29 years old, each concerning his own learning from childhood to his present age. This testimony is also useful in several other ways.

It was given in the form of answers to 163 questions. These are printed below in full, partly because an examination of them will make the discussion clearer and easier to follow, and partly because any reader of this volume will probably be curious to record his own answers and compare himself with others. The group reported here (ninety-nine in all) consists of teachers and professional men and a few home makers. All had a college education or its equivalent. About three fourths of them gave the testimony simply and solely as a favor to us. The other fourth may have included some who gave the testimony because they were specially interested in adult learning; and perhaps they represent somewhat more than the average learning in late years and somewhat higher estimates of its ease than a random sampling would give.

I. E. R. Information Blank

Learning A.

Write your name here.....

Date of filling this blank.....

Identification..... Age.....years.....months

In the case of each of the forty acts or habits or accomplishments listed below, write how old you were when you learned it. Use one number such as 14 or 16 or 19, if it was learned in a year or less. Use two numbers such as 14 to 17, or 20 to 21, representing your age at the beginning and end of the learning if more than a year was required to learn it. Then answer this question (Question 1) about the act or habit or accomplishment, "If I had not learned it, could I now learn it?" Write "yes" or "no". Then answer this question (Question 2), "If I had not learned it until now, would it require more practice or less practice to make the same progress than was required when I learned it?" Write "more" or "less". If you never have learned the thing, write "no" and answer question 1 only.

Answer the questions even if your opinion is a mere guess.

	Age of learning	*Quest. 1*	*Quest. 2*
1. To swim			
2. To skate			
3. To dance			
4. To drive an automobile			
5. To sail a boat			
6. To ride horseback			
7. To ride a bicycle			
8. To play the piano			
9. To play the violin			
10. To typewrite			
11. To eat olives			
12. To eat spinach			
13. To eat tomatoes			
14. To eat raw oysters			
15. To drink tea			
16. To drink coffee			
17. To drink alcoholic beverages			
18. To smoke tobacco			
19. To give up drinking tea			

	Age of learning	*Quest. 1*	*Quest. 2*
20. To give up drinking coffee	_____	_____	_____
21. To give up drinking alcoholic beverages	_____	_____	_____
22. To give up smoking	_____	_____	_____
23. To read French	_____	_____	_____
24. To read German	_____	_____	_____
25. To read Latin	_____	_____	_____
26. To read _____ Insert the name of the language	_____	_____	_____
27. To read _____ Insert the name of the language	_____	_____	_____
28. To speak French	_____	_____	_____
29. To speak German	_____	_____	_____
30. To speak Latin	_____	_____	_____
31. To speak _____ Insert the name of the language	_____	_____	_____
32. To speak _____ Insert the name of the language	_____	_____	_____
33. To use logarithms	_____	_____	_____
34. To use sines, cosines, and tangents	_____	_____	_____
35. To use the elements of calculus	_____	_____	_____
36. To use shorthand	_____	_____	_____
37. To play chess	_____	_____	_____
38. To speak in public	_____	_____	_____
39. To teach school	_____	_____	_____
40. To earn your own living	_____	_____	_____

Please answer questions 41 to 83. The purpose is to get facts concerning the age of changes in attitudes and opinions. In cases where you cannot answer *yes* or *no*, use any form of answer that will give the facts. In cases where the change came gradually during several years, describe the period of change, as 17 to 20, or 10 to 16, or 21 to 30, or the like. You will observe that the "At what age" questions are to be answered only if there has been a change in the attitude or opinion in question.

41. Are you now afraid of or annoyed by thunder? ____.
42. Were you ever afraid of or annoyed by thunder? ____.
43. At what age did you get over the fear or annoyance? ____.
44. Are snakes now objects of fear or repulsion to you? ____.
45. Were they ever objects of fear or repulsion to you? ____.
46. At what age did you get over the fear or repulsion? ____.
47. Are mice now objects of fear or repulsion or nervousness to you? ____.
48. Were they ever objects of fear or repulsion or nervousness to you? ____.

49. At what age did you get over the fear or repulsion or nervousness? ____.
50. Does the sight and smell of blood now disturb you? ____.
51. Did the sight and smell of blood ever disturb you? ____
52. At what age did you get over being disturbed by it? ____.
53. Do you now have sudden fits of rage or of depression or of excitement? ____.
54. Did you ever have them? ____
55. At what age did you get over having them? ____.
56. Are you a member of a religious denomination or church? ____.
57. At what age did you join the church? ____.
58. Do you now attend church at least 30 times a year? ____.
59. If your answer to 58 is "No," at what age did you stop regular attendance at church? ____.
60. Do you now think that Jonah lived for days inside a whale's belly? ____.
61. Did you ever think that Jonah lived for days inside a whale? ____.
62. At what age did you change your opinion? ____.
63. Do you now think that Judas Iscariot, Nero, and such people are suffering bodily torture in a special place called Hell? ____.
64. Did you ever think so? ____.
65. At what age did you change your opinion? ____.
66. Do you now think that when you die you will live again in a world much like this, where you will see and hear and talk with other persons, and play games and move from place to place, and the like? ____.
67. Did you ever think so? ____.
68. At what age did you change your opinion? ____.
69. Do you now think that the Jews in this country are on the average less worthy of esteem than the Christians? ____.
70. Did you ever think so? ____.
71. At what age did you change your opinion? ____.
72. Do you now think that the early colonists treated the Indians much better than the Indians treated the colonists? ____.
73. Did you ever think so? ____.
74. At what age did you change your opinion? ____.
75. Do you now think that England was at least 80 per cent wrong and the colonies at least 80 per cent right in the disputes which gave rise to the Revolutionary War? ____.
76. Did you ever think so? ____.
77. At what age did you change your opinion? ____.
78. Do you now think that the Republican Party is very much superior to the Democratic party? ____.
79. Did you ever think so? ____.
80. At what age did you change your opinion? ____.

81. Do you now think that the Democratic party is very much superior to the Republican party? ____.
82. Did you ever think so? ____.
83. At what age did you change your opinion? ____.

Learning to swim, skate, and dance may be taken as fair samples of learning in athletics. Age is evidently not an insuperable barrier, learning to swim and dance occurring at all ages to 50. The influence of interest and custom is seen in the fact that swimming is learned late especially by the women, while dancing is learned late especially by the men. There is an enormous majority of opinion (71 to 9) that these athletic skills would be harder to learn at the late ages over forty than they were at the earlier. The majority is not so strong in those of 30 to 39 (66 to 33). The facts appear in Table 41, below.

TABLE 41

Testimony of adults: learning to swim, skate and dance.

	SWIMMING				SKATING				DANCING					
	40 or +		30–39		40 or +		30–39		40 or +		30–39			
	M	F	M	F	M	F	M	F	M	F	M	F		
Not learning	0	12	2	7	4	11	1	7	4	4	6	2		
Learning .	14	13	22	12	10	14	23	12	10	20	18	17		
Learning at														
0– 4												1		
5– 9	3		6	1	4	4	8	3	1	2		4		
10–14	5	2	9	1	4	7	7	6	1	7	1	6		
15–19	2	1	1	2	2	2	5	1	3	6	8	3		
20–24	3	1	3	3		1	1	1	1	3	4	1		
25–29		1		1			2	1	1	1	2	2		
30–34		1	2	2					2	1	3			
35–39	1		1	2										
40–44		4							1					
45–49		2												
50 or over		1												
													40or +	30–39
Easier . .	2	0	8	1		1	9	1	1	1	1	1	5	21
Equal . .	1	1	2	2			2		2		4	2	4	12
Harder .	11	11	10	9	10	13	10	11	7	19	12	14	71	66
Not stated		1	2				2	1			1		1	6

Learning to drive an automobile, sail a boat, ride horseback, and ride a bicycle are fair samples of semiathletic and semitechnical skills. They also show a very wide age range. There is a large, but not overwhelming, majority (61 to 21) of the opinion that these skills would be harder to acquire after forty than when they were acquired. For the group aged 30 to 39, the vote is 59 to 43. Table 42, below, reports the facts.

TABLE 42

Testimony of adults: learning to drive an automobile, sail a boat, ride horseback and ride a bicycle.

	Driving Auto				Sailing Boat				Riding Horse				Riding Bicycle					
	40 or +		30–39		40 or +		30–39		40 or +		30–39		40 or +		30–39			
	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F		
Not learning	1	14	1	4	12	22	20	16	2	13	4	2	1	9	0	4		
Learning	13	11	23	15	2	3	4	3	12	12	20	14	13	16	24	12		
Learning at																		
0– 4									1	1								
5– 9									5	3	12	2	2		2	4		
10–14					1	2	1	2	5	5	3	6	6	9	18	7		
15–19			1	1		1	2	1		1	2	1		4	3			
20–24	1		8	4			1		1		2		3	3	1			
25–29			7	5						2		3	1					
30–34	3	2	7	3							1	2	1			1		
35–39	2	4		2	1													
40–44	6	2																
45–49	1	3																
50 or over																		
																	40 or +	30–39
Easier		1	6	1	1	2	3		2	3	8	3	1	1	9	1	11	31
Equal	4	5	7	3							1	1	1		2		10	12
Harder	9	5	8	10	1	1	1	3	10	9	8	9	11	15	10	10	61	59
Not stated			2	1							3	1			1	1		8

Learning to play the piano and to typewrite are two common samples of a complex system of sensorimotor skills. The former is, in general and especially in its higher possibilities, much the harder. The testimony is summarized

in Table 43, below. There is a wide range of dates for typewriting. Learning to play the piano is, as was stated earlier, distinctly an achievement of childhood, not probably because of any limitations, in adolescence and adult

TABLE 43

Testimony of adults: learning to play the piano and to typewrite.

	PLAYING THE PIANO				TYPEWRITING					
	40 or +		30–39		40 or +		30–39			
	M	F	M	F	M	F	M	F		
Not learning	10	6	15	7	3	10	6	4		
Learning	4	19	9	12	11	15	18	15		
Learning at										
0– 4										
5– 9	2	6	2	6						
10–14	1	10	7	5	1		1	1		
15–19		1					4	1		
20–24		1		1	2	1	4	3		
25–29	1				3	3	6	4		
30–34					1	3	3	3		
35–39		1			2	1		3		
40–44					2	3				
45–49						3				
50 or over						1				
									40 or +	30–39
Easier	1	3	4	2	2	4	4	2	10	12
Equal		1		1	3	4	4	2	8	7
Harder	3	15	5	9	6	7	8	10	31	32
Not stated							2	1		3

years, to the abilities required. There is a strong majority of the opinion that these accomplishments would be harder to learn at the present ages than at the ages when they were learned, a majority about the same as in the case of driving an auto, sailing a boat, riding a horse and riding a bicycle.

The reports concerning learning to eat olives, spinach, and raw oysters and to drink tea and coffee do not differ appreciably and the sexes do not differ appreciably with respect to them. All these reports may be considered together. They appear in Table 44, below. There is a very wide age range. The general opinion is that these

TABLE 44

Testimony of adults: food habits — learning to eat olives, spinach, etc., and to drink tea and coffee.

	40 OR +	30–39
Not learning	19	21
Learning	176	194
Learning at		
0– 4	17	24
5– 9	43	41
10–14	37	53
15–19	31	39
20–24	25	21
25–29	10	7
30–34	8	9
35–39	1	
40–44	3	
45–49	1	
50 or over		
Easier	105	102
Equal	16	33
Harder	49	40
Not stated	6	19

food habits would be easier to form after forty than when formed. The 30 to 39 group confirms this testimony. Tomatoes (which are somewhat more attractive to the natural palate) are eaten earlier, but the testimony is emphatic that the habit would be easier to form in later years. The distribution of the learning is for 0 to 4, 5 to 9, etc., in order, 10, 14, 4, 3, 2, 1, 1, 1. The vote is: easier 28, equal 3, harder 4.

The number who drank or smoked was too small to justify any detailed analysis. The general condition seemed to be the same as that for the food habits just described.

The number of cases who had given up tea, coffee, alcohol, or tobacco was very scant. We lump them all together in Table 45. These habits are broken at all ages up to the time of the record, and there is only a small majority of the opinion that they become harder to break.

TABLE 45

Testimony of adults: giving up tea, coffee, alcohol, and tobacco.

	40 OR +	30–39
Breaking the habit	24	18
Breaking habit at		
0– 4		
5– 9		
10–14	2	2
15–19	2	1
20–24	5	3
25–29		8
30–34	5	4
35–39	1	
40–44	2	
45–49	6	
50 or +	1	
Easier	9	1
Equal	2	4
Harder	8	10
Not stated	5	3

The facts for learning languages do not differ with sex, so we combine the records. The facts appear in Table 46, pages 116–117. Latin is learned only by the young, but not probably because of any special inability at later ages. The facts for French and German are doubtless due partly to the presence of some of the persons concerned in France during the War, and to the antipathy then aroused toward

things German. There is, except for Latin, a wide range of learning. There is a slight majority of opinion that learning to read languages becomes harder at the late ages; there is an emphatic majority to the effect that learning to speak languages is harder then. The element of motor skill is of almost or quite zero influence in learning to read a language, but counts somewhat in learning to speak, unless a person is content to pronounce barbarously, and fail more or less to make himself understood as a consequence.

TABLE 46

Testimony of adults: learning a foreign language.

	Learning to Read									
	Latin		French		German		Other Languages			
	40 or +	30–39	40 or +	30–39	40 or +	30–39	40 or +	30–39		
Not learning	6	6	13	17	9	8	?	?		
Learning	33	37	26	26	30	35	18	19		
Learning at										
0– 4										
5– 9		1			4	1	3	1		
10–14	18	17	4	5	6	7	3			
15–19	9	16	9	6	11	21	2	5		
20–24	5	3	2	5	2	4	4	5		
25–29	1		3	5	5	1	2	3		
30–34			4	4		1		4		
35–39			1	1	1		2	1		
40–44			1				2			
45–49					1					
50 or +			2							
									40 or +	30–39
Easier	10	15	7	10	11	17	6	9	34	51
Equal	1		1	1	1		4		7	1
Harder	18	19	16	13	15	18	8	8	57	58
Not stated	4	3	2	2	3			2	9	7

TABLE 46 — *Continued*

Testimony of adults: learning a foreign language.

	LEARNING TO SPEAK									
	Latin		French		German		Other Languages			
	40 or +	30–39	40 or +	30–39	40 or +	30–39	40 or +	30–39		
Not learning	39	36	27	29	24	20	?	?		
Learning	0	7	12	14	15	23	3	11		
Learning at										
0– 4					3		2			
5– 9		1			2	2		1		
10–14		2		3	2	4				
15–19		3	4	4	3	10		1		
20–24		1	1	4	2	4	1	3		
25–29			2	1	2	3		3		
30–34			1	2				3		
35–39			1							
40–44			1		1					
45–49										
50 or +			2							
									40 or +	30–39
Easier		3	2	3	3	5		1	5	12
Equal			1	1		2			1	3
Harder		3	9	8	12	16	3	9	24	36
Not stated		1		2				1		4

Learning to use logarithms, the trigonometric functions, and calculus are samples of the learning of abstract, symbolic, and highly systematic content in which there is substantially zero requirement of motor skill. The facts appear in Table 47, page 118, where the facts for chess are also reported. Learning chess is a somewhat similar form of learning. There is a strong majority to the effect that these things are easier to learn at the late ages.

TABLE 47

Testimony of adults: learning abstractions and symbols.

	LOGARITHMS		TRIGONOMETRY		CALCULUS		CHESS			
	40 or +	30–39	40 or +	30–39	40 or +	30–39	40 or +	30–39		
Not learning	11	10	13	9	28	31	24	31		
Learning	28	33	26	34	11	12	15	12		
Learning at										
0– 4								1		
5– 9							4	3		
10–14	16	18	14	19	3	3	3	5		
15–19	8	13	8	13	7	4	1	1		
20–24	3	2	3	2	1	4	2	2		
25–29						1	1			
30–34							1			
35–39	1		1							
40–44							2			
45–49							1			
50 or +										
									40 or +	30–39
Easier	13	20	11	20	6	7	7	7	37	54
Equal	1	2	1	2	1	1	1	3	4	8
Harder	14	8	14	8	4	3	6	1	38	20
Not stated		3		4		1	1	1	1	9

Learning to speak in public was inserted in the list in order to have at least one case where the element of sensitiveness to the reactions of others to one's personality would be conspicuous. It would have been wise to have had further cases; for the testimony as a whole seems to show that the difficulty, or expectation of difficulty, of learning at late ages is not chiefly a matter of intellect, but of motor skill and of fear of ridicule or other adverse social comment. The vote for those 40 or over who have learned to speak in public is 7 for "easier" and 27 for "harder." For those 30 to 39 it is 6 for "easier," 4 for

"equal," and 26 for "harder." The age range is from 2 to 45.

Learning to earn a living is perhaps the most important lesson one learns. The facts for learning to teach are reported with it (in Table 48), below, since for this

TABLE 48

Testimony of adults: earning a living and teaching school.

	Earn a Living		Teach School			
	40 or +	30–39	40 or +	30–39		
Not learning	3	0	3	5		
Learning	36	43	36	38		
Learning at						
0– 4						
5– 9		1				
10–14	3	3				
15–19	12	19	15	15		
20–24	20	20	17	18		
25–29	1		3	5		
30–34						
35–39			1			
40–44						
45–49						
50 or +						
					40 or +	30–39
Easier	13	15	9	16	22	31
Equal		3				3
Harder	23	12	25	16	48	28
Not stated		13	2	6	2	19

group they are often the same. The age of first earning a living was from 15 to 25 in almost all cases, and was later than 25 in only two. So we have here a clear comparison of late adolescent or early adult with late adult learning in the estimates of relative difficulty. Those now 40 or over vote about 2 to 1 that it would now be

harder. Those 30 to 39 split almost evenly. We have previously had evidence of a similar difference between these two groups. In swimming, skating, and dancing; in driving a car, sailing a boat, etc.; and to a less degree in learning to read and speak languages, to use mathematical symbols, and to speak in public, it holds good. In everything so far considered, save the food habits, the years after 40 are considered to be at a disadvantage compared to the years from 30 to 39, in this indirect comparison.

The testimony concerning thunder, snakes, mice, blood, and fits of rage is reported in Table 49, page 121. The interpretation of this testimony will depend somewhat upon one's general views as to the causation of the condition in the first instance, and as to the amount of effort made by the group to overcome them. One view would consider that all persons are by nature more or less subject to them and that the large number of the *nevers* is evidence that they are far more easily overcome at the time of the first manifestations in early childhood than later. Another view would consider that they were all caused by unfortunate mental connections made in infancy and that the large number of the *always* replies is evidence that the persons have not tried very hard to overcome them or are in some peculiar pathological condition in respect to them. There are other possible and more moderate views.

We need not for our present purpose try to decide concerning the relative importance of infancy and later years in learning or unlearning these connections. If our testimony is true, we at least know that they can be unlearned at any age from 5 to 50. The repulsiveness of snakes, which is the strongest of the five, has been the subject of much practical investigation by Mr. B. T. B. Hyde, who is constantly curing people of all ages. In our records it is overcome as often after 20 as before.

TABLE 49

Testimony of adults: emotional attitudes.

	MEN 40 OR +						WOMEN 40 OR +						TOTAL FOR MEN AND WOMEN
	Thunder	Snakes	Mice	Blood	Rage	Total	Thunder	Snakes	Mice	Blood	Rage	Total	
Never	9	3	11	10	9	42	10	4	9	11	14	48	90
Always	3	7	3	3	3	19	6	17	15	10	6	54	73
Overcoming	2	3	0	1	2	8	9	4	1	4	5	23	31
Overcoming at													
0– 4													
5– 9	1					1							1
10–14					1	1	4			1	1	6	7
15–19	1	1				2	4	1		2	2	9	11
20–24				1	1	2		1				1	3
25–29		1				1		1				1	2
30–34								1			1	2	2
35–39							1			1		2	2
40–44									1			1	1
45–49											1	1	1
50 or +													
No date given		1				1							1
	MEN 30–39						WOMEN 30–39						
Never	14	5	17	15	12	63	11	6	8	8	10	43	106
Always	1	16	6	5	5	33	3	12	10	7	3	35	68
Overcoming	9	3	1	4	6	23	5	1	1	3	6	16	39
Overcoming at													
0– 4													
5– 9	3				1	4	1					1	5
10–14	1	1	1	2	1	6	1				1	2	8
15–19	4	2		1	1	8					1	1	9
20–24	1				2	3	2		1	2	3	8	11
25–29				1		1	1					1	2
30–34					1	1		1			1	2	3
35–39													
40–44													
45–49													
50 or +													
No date given										1		1	1

The testimony concerning church membership and attendance shows that whereas most persons of the group joined the church between 9 and 16 and began to neglect it (if they did at all) after 20, some joined at a very late age, and some began to neglect it very early.

Questions 60 to 83 concern common beliefs and prejudices, representative of the potent forces which cause or are used in support of crusades, charities, persecutions, wars, and much else of the best and the worst that the world knows. The ones chosen are such as an intelligent and educated group has been giving up in the past twenty years, but the psychology of age in relation to beneficent ones acquired would be the same. The facts appear in Table 50, page 123. The great majority of those who held these beliefs and prejudices changed them (78 to 34 and 92 to 26). The three beliefs changed chiefly from 10 to 34; the four prejudices changed almost five years later, that is, chiefly from 15 to 39.

These reports furnish evidence that the age at which a thing is learned is determined by other factors besides the possession of enough ability to learn it. Thus, skating and dancing are very much alike in the abilities which they require, but are very different in age of learning. If a person does not learn to skate by the age of 20, he very seldom learns later, but dancing is learned at almost every age.

Typewriting, so far as concerns the abilities required, could be learned very early along with reading and with or before handwriting. It is actually learned very late, the median age being 32 for persons 40 years or older. Playing the piano could be learned probably at any age to forty, but is in fact learned before 14 (date of beginning) in more than four fifths of the cases.

Learning to sail a boat and to drive an automobile depend upon much the same abilities and interests, but for the group aged forty or over, in 1926, the dates of

Table 50

Testimony of adults: beliefs and prejudices.

	Those Reporting at 40 or +																	
	1		2		3				5		6		7		8			
	Jonah		Physical hell		Physical heaven		1, 2, and 3		Jews		Indians		England		Political party		5, 6, 7, and 8	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
Never held	7	6	6	12	2	4	15	22	8	11	3	8	1		?	?	?	?
Maintained		3		1	2	7	2	11	2	4			6	15	6	1	14	20
Changed .	7	16	8	11	10	10	25	37	3	9	10	17	6	8	9	16	28	50
Changed at																		
0– 4																		
5– 9																		
10–14	2	3	1	2	2	3	5	8			1	1					1	1
15–19	1	4	1	2	1	2	3	8			1	5		2		4	1	11
20–24	2	4	1	3	3	3	6	10	2	1	3	2	2		3	2	10	5
25–29	2	1	2	1	2	1	6	3		2	1	3	1	1	3		5	6
30–34		2	1	2	1	2	2	6	1	3	3	1	3	3	1	5	8	12
35–39										3		3		2		2		10
40–44			1		1		2								1	1	1	1
45–49		1						1										
50 or +																		
No age given		1	1	1			1	2			1	2			1	2	2	4

	Those Reporting at 30–39																	
Never held	6	5	5	8	8	7	19	20	14	9	6	8	1	3			21	20
Maintained		4		1	2	3	2	8	1	3	1	2	6	7	1	5	9	17
Changed .	18	10	19	10	14	8	51	28	9	5	17	9	16	9	18	9	60	32
Changed at																		
0– 4																		
5– 9	1		1				2											
10–14	5		3	3	3	1	11	4			2	1	1		2		5	1
15–19	6	6	10	6	3	3	19	15	2		4	4	2	3	3	4	11	11
20–24	4	2	5	1	6	2	15	5	2	2	8	3	9	3	9	3	28	11
25–29		1			1	2	1	3	3	2	2	1	4	3	3	2	12	8
30–34	1				1		2		1		1				1		3	
35–39									1	1							1	1
40–44																		
45–49																		
50 or +																		
No age given	1	1					1	1										

learning are in sharp contrast. Only one person learned to drive an automobile *before* he was thirty and only one person learned to sail a boat *after* he was sixteen.[1]

Such cases suggest that the time at which people learn things depends in large part upon when they wish to learn them, or when they are urged to learn them, or when they have the opportunity to learn them. Similarly the fact that many learned to read French or German after 25, but nobody learned Latin after then has no significance concerning the age relations of the abilities to learn these languages. Its significance concerns interests and customs.

In general the testimony of this group indicates (1) that almost anything is learnable at any time up to fifty, (2) that the experience of these individuals leads them to expect more difficulty in learning from forty on than from thirty to thirty-nine, except with making and breaking food habits, (3) that the difficulty expected from thirty up to forty is no greater than for childhood or adolescent years in the case of intellectual acquisition pure and simple, and (4) that, in general, age seems to them to influence the power of intellectual acquisition very much less than it influences motor skill.[2] There is evidence also that (5) the difficulty expected in learning at late ages is in part due to a sensitiveness to ridicule, adverse comment, and undesired attention, so that if it were customary for mature and old people to learn to swim and ride bicycles and speak German, the difficulty might diminish.[3]

None of the expected differences in difficulty are of very great magnitude. The greatest is for swimming, skating,

[1] If we had only our records of persons 40 years or more old, the natural conclusion would be that a person could not learn to drive an automobile until he was thirty!

[2] Age 30 to 39 is the preferred age for learning abstract mathematics and chess.

[3] Public speaking is regarded as getting added difficulty from age to an extent greater than teaching does. Speaking a language is regarded as getting a much greater increment of difficulty from age than reading it, greater than the motor element *per se* seems able to account for.

and dancing, and even for them a substantial minority consider that it would be as easy or easier for them to learn at forty or over as it was at the time of learning. If the absolute differences were very great there would be unanimity concerning the direction of the difference.

The real differences are probably in most cases less than the expected, for the following reasons: These individuals, who surveyed their learning in retrospect, probably underestimated the amount of time spent in the water or on the ice, etc., etc., in childhood's learning. They probably confuse interest in learning with ability to learn to some extent. So far as they were prejudiced at all, they were probably prejudiced in favor of the orthodox doctrine that, after adolescence, each year in some mysterious way weakens the power to learn.

The facts reported in this chapter seem to us to show that adults learn much less than they might partly because they underestimate their power of learning, and partly because of unpleasant attention and comment. The facts of the chapter are also in harmony with the assumption that adults learn less than they might because they do not care enough about learning. There is nothing in the testimony that need weaken our conclusions, previously made from the experimental results.

CHAPTER XI

The Causes of the Age-Changes in Ability to Learn and in Amount Learned

The facts reported in Chapters II to IX show that the curve of ability to learn[1] in relation to age from five to forty-five is approximately of the form shown in Figure 8, page 127. We inquire now concerning the causes which determine it.

We may consider any individual's ability to learn at any epoch in his life up to forty-five as a resultant of six factors.

[1] We have spoken, and shall continue to speak, of "the ability to learn" as if men could be measured in all sorts of learning and compared justly in respect of a total average ability to learn computed from the results. It is convenient to do so, and no harm will result, if the reader will bear in mind that such computations and comparisons have not been attained and may be unattainable. All that we really claim to do is to take an unprejudiced sampling of different sorts of learning and compute results from them in an unprejudiced way; and so get comparisons which are as likely to favor one age as another, so far as we know, and to be impartial approximations as to what would be found if every act of learning in every man could be measured and given its proper weight, as a determiner of a total or average ability to learn.

Such a total or average ability in which different ages may be compared may be unattainable. Different forms of learning may be so specialized in relation to age, one falling off rapidly while another remains unimpaired, that very different total estimates of ability to learn will result according to different ideas of the relative importance of the forms of learning *inter se*. Some things learnable at age twenty may be unlearnable at age forty, for example, because everyone has learned them before then, so that the total can never include them. A rigorous treatment demands that each particular act of learning be studied by itself.

There are other complexities and qualifications which critical study of what the results of Chapters II to X imply would reveal, concerning ability to learn or abilities to learn. Such a study would reveal that nobody knows, or can know in the present stage of psychology, exactly what our results do mean. We do know, however, roughly and vaguely, that the old-young ratios or per cents of gain mean something approximating not unfairly to ratios of amount learned per unit of time of things such as people need to learn; and the impression which a careful reader has gained from these old-young ratios will not mislead him.

The first is his amount of inborn capacity to develop the ability to learn, whereby even if he were treated identically with other men or animals he would learn better or less well than they. The second is the extent and manner in which the inner growth of the ability to learn has proceeded in his case. His ability to learn changes year by year under the influences of internal developmental forces which are much the same in their independence of outside experience as those which make him grow taller and

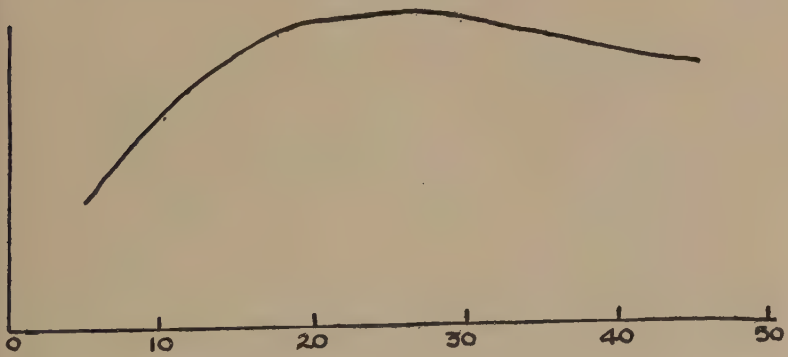


FIG. 8. THE GENERAL FORM OF THE CURVE OF ABILITY TO LEARN IN RELATION TO AGE.

stronger. If by a miracle a child of ten could be kept alive and well, but in a dreamless sleep, for a year and then waked up to resume its ordinary life, it would not thereafter be a year behind in ability to learn. A year brings growth from within as well as training from without, and the loss of the latter need not involve, in theory at least, the loss of the former. In fact, of course, growth from within and training from without coöperate intimately. The third factor is a possible degenerative effect of late age, an opposite of the inner-growth factor of early age, a deterioration whereby the individual, after having grown to a higher degree of ability to learn, and after

having gained better methods and tools of learning, loses it, or them, or both.

The fourth and fifth factors are the two sorts of influence, specific and general, exerted by training or experience. Working upon and with the inborn capacity and developing power of an individual, training forms certain habits of learning, and provides certain tools to learn with. These are mostly composites of rather specific things, such as the habits of holding a book right side up and of reading from left to right, and the knowledge of words, numbers, and the like, which are such potent aids in learning. They constitute the fourth factor. The general influence of training in making an individual better fitted as a whole to learn (as by some subtle gain in the ability to concentrate on anything, or the ability to retain anything experienced, or the general ability to call up serviceable rather than unrelated facts) is largely mythical, but there is more to training than the words "forming habits" and "providing tools" are likely to mean to most of us. This "more," representing the habits of very wide application, the tools which can serve in an enormous number of situations and those subtler habits which we usually call ideals, attitudes, methods of procedure and the like, is the fifth factor.

The sixth factor is the general effect of the lapse of time without use upon acquired abilities. In so far as the abilities to learn have been increased by training, they may be expected to decrease when years pass with little or no exercise of them. Although this has not hitherto, to our knowledge, been brought forward as a cause of decline with age, it may be a very important one.

Capacity

We are concerned with an individual's capacity only in so far as there might be a tendency for the greater capa-

cities to resist effects of age longer than the smaller capacities. We saw in Chapters II to VII (and in Appendix I) that there was no evidence of this, so that we are free to apply facts discovered about the curve of learning ability with age for those with greater learning capacity, such as university students or the professional classes, to the curve of learning ability with age in groups of lower capacity.

Inner Growth

The general fact that inner growth changes and increases the ability to learn is of obvious importance to our inquiry; and so is the approximate date of cessation of inner growth in respect of ability to learn. This latter probably varies for different abilities. Its general average or mode seems from our results to be somewhere near twenty, though psychologists in general would probably be inclined to set it somewhat earlier. Consequently we can assert with reasonable surety that the fact of inner growth favors adults in comparison with children. Unless it is counterbalanced by factors acting in the opposite direction, inner growth gives the person from twenty-five to forty-five as good an ability to learn as he had from twenty to twenty-five, a better ability than he had from fifteen to twenty, and a much better ability than he had from five to fifteen.

The inner growth of the ability to learn is often misinterpreted as a result of learning itself. A common line of thought concerning learning in childhood and in adult years runs like this: "The great bulk of human learning occurs in childhood and adolescence. Compare the child at birth, at five, at ten, at fifteen, and at twenty. In each five-year period he makes great advances, especially in the first. No such progress is shown by the adult. He is much the same at forty that he was at thirty-five or at

thirty or at twenty-five. The progress of the first five years is enormously greater than all that made in thirty years of adult life. Childhood is the time for learning. A little training then produces enormous returns."

Such a train of thought involves one or more of three errors.

First, it may be due to a confusion of percentile increments with absolute increments. If a child could and did learn at the constant rate of one unit a day for each day of his life till he was ten, he would on the first day improve his total amount learned infinitely, on the second day by 100% and on the last day by about one thirtieth of one per cent.

Second, it may be due to a confusion of changes in the degree of difficulty of what can be learned with changes in the ability to learn in the sense of the amount learnable per unit of time. The degrees of difficulty of the intellectual tasks which can be accomplished by the average five-year-old, twenty-five-year-old, and forty-five-year-old respectively are in something like the proportions 27, 37, and 37. But this does not in the least mean that the adult learns nothing from twenty-five to forty-five, or that the child learns 2.7 times as much in the first five years as in the next twenty.

In the third place, the changes in early years to which the statements which we are criticizing direct our attention are not ones which were produced by a "little training" in childhood, or by any amount of training alone. They were produced by training plus inner growth. Childhood and adolescence *are* the optimum time for inner growth in the ability to learn, and we should be careful to allow for this in any estimates of the returns produced by training.

The possible truth in these common statements is the suggestion that the time when the mind is growing by inner forces may be the best time to make it grow in de-

sirable ways. If we wish to change the shape of the skull, we succeed better by applying our bands and compresses when the skull is growing than after it is full grown. And something somewhat analogical may sometimes be true of mental habits, powers, and interests. In such cases, however, the advantage is due to the avoidance of contrary interests and of practice in error, not to the presence of superior ability to learn.

The Degenerative Effect of Age

It is a matter of common knowledge that at very late ages, say from seventy on, many persons show a notable decline in the amount of learning per year, so that they do not learn as much as they forget and fall back in the amount of knowledge or skill. We have presented evidence (in Appendix I) that at about fifty-five the net result of changes in general energy, interest in one's work, and ability to improve is a regression in achievement. There can be but little doubt that at some time between twenty and ninety the inner developmental forces which made the ability to learn wax give place in most persons to other inner influences which make it wane. But the time of their onset and the course they pursue is not known. Nor is it known whether this inner degeneration tears down only what inner growth has built up, or only what the training of life has built up, or both. It is, however, probable that the last is the case. Nature and nurture coöperate so intimately in the development of man's abilities that it would probably be hard for any general physiological forces to separate out for deterioration facts due to inner growth alone or facts due to training alone. How far this decline is due to lessened ability and how far to lessened desire to learn is not known, but few psychologists would credit the entire change to desire alone.

Training

The influence of training should (with occasional exceptions due to the formation of bad habits) cause an increase in the ability to learn with age, so long as each year of age brings training with it. Indeed, if the claims of the advocates of mental discipline of a generation ago were valid, a person should add enormously to his ability to learn by the training of school and college years.

The Action of Disuse upon the Ability to Learn

It is well known that isolated connections formed or strengthened by training, such as between $\sqrt[3]{\ }$ and "*cube root of*" or between "*amare*" and "*to love*," weaken when time elapses without their being used. There is some question whether such abilities as singing, playing tennis, writing poetry, solving originals in geometry, or being tactful in negotiations, in so far as they have been improved by training, also deteriorate by disuse. They often seem to do so more slowly than isolated connections, because they have been "overlearned" (that is, learned more thoroughly than was necessary to just establish them); and some psychologists have thought that time could improve complex abilities by purging them of their harmful features. The bulk of the evidence goes to justify the hypothesis that any change produced by training tends to be lost by the lapse of time without practice. We ought then probably to infer that gain in ability to learn acts of skill, or in the ability to learn a new language, or in the ability to learn a new code, or in the total average ability to learn, in so far as it was produced by training,[1] would be lost by the lapse of time without practice in learning acts of skill or language or codes or things in general.

[1] Whether disuse weakens connections, abilities, and interests which arose by inner growth is a question which we shall not try to answer.

If, then, a man ceased at thirty to learn, he would, other things being equal, lose gradually such gains in ability to learn as he had acquired by school or other training in learning before thirty. Even if there was no natural process of fall in the power to learn, corresponding to its rise in childhood and adolescence, a man might yet lose the power to learn for the same reason that he loses the names of his early teachers, or the facts of algebra or Latin.

This sixth factor is important because it is subject to our control, or rather to counterbalancing action by us. If we keep on learning we may expect to lose less of our ability to learn. We might even increase it enough year by year by practice to outweigh the losses due to the third factor of a weakening due to an essential, unavoidable inner decay.

It would be interesting and for some purposes important to try to assign shares in the general rise in ability to learn to about twenty and its general slow decline from about twenty-five to forty-five, to inner growth, inner decay, special training, and loss by disuse. But much more elaborate researches are necessary before this can be done safely.

In particular, we should like to know how far the decline from twenty-two to forty-two is due to an inner process of decay which is unavoidable or avoidable only by biochemical means, as yet undiscovered, and how far it is due to disuse, which can be avoided if men simply continue to learn. We may make progress toward a provisional answer to this question by considering: (*a*) what is known concerning changes in abilities in general during this period, (*b*) the relation of ability to learn to age in the lower animals, and (*c*) the fitness of degeneration and disuse to explain the facts of Chapters II to IX.

Ruger and Stoessinger ('27, p. 87 f.), working with the measurements collected by Francis Galton, have computed the growth curves for Pull, Grip, Swiftness of Blow,

Sense of Perpendicularity, Error of Bisection, and Error of Trisection. From their reports we get the facts of Table 51, below.

TABLE 51

Age changes in strength, speed and sensory discrimination.

	AVERAGE SCORE AT 22½	AVERAGE SCORE AT 42½	DIFFERENCES	AGE OF APPROXIMATE ACME	ESTIMATED GAIN, AGE 10 TO 15	PER CENT WHICH LOSS 22½ TO 42½ IS OF AVERAGE GAIN FOR ONE YEAR 10 TO 15
Pull	73.80 lb.	71.60	2.20	25	17.85	.62
Grip (right hand)	82.16 "	81.13	1.03	25	24.23	.21
Grip (left hand) .	78.71 "	78.50	.21	25	20.57	.04
Swiftness of blow	18.27 ft. sec.	17.67	.60	22	3.43	.87
Sense of perpendicularity . . .	.292 degrees	.312	.020	21	.169	.59
Error of bisection	.854% error	.881	.027	25	.143	.95
Error of trisection	1.223% error	1.251	.028	23	.698	.20

The drop in these twenty years in these characters of strength, speed, and sensory discrimination is slight, about half as much as the average gain in a single year from ten to fifteen, and two and one half per cent of the score at twenty-two and one half.

By the courtesy of Prof. W. F. Book and Dr. T. E. Nicholson of the University of Indiana, we have been permitted to use data from an unpublished study by Dr. Nicholson of "The Increase and Decline in Speed and Control of Voluntary Motor Ability with Advancement in Age" (1925). Dr. Nicholson measured the rate of tapping by finger movement, wrist movement, elbow movement, and shoulder movement in individuals from 17 to over 80 years of age. The subjects (25 men and 25 women at each year of age) were selected as follows:

For the earlier ages, seventeen to about twenty-five, pupils in the Bloomington High School and students in Indiana University were used as subjects.

For the more advanced ages, subjects were secured in the psychology booth of the Indiana University Exhibition Building at the Indiana State Fair at Indianapolis in 1923 and 1924; also in the lobbies of the Indianapolis hotels and in the lobbies of the railroad passenger stations at Indianapolis and at Bloomington, Indiana. A booth was also set up at the Monroe County Fair at Bloomington in 1923 and 1924 where records were obtained from many subjects.

We have thus somewhat superior individuals at ages 17 to 23, and probably at ages 65 and over, since abler old people would be more likely to be about and readier to try such tests than the less able. From 25 to 60 there is probably a fairly random selection of the living.

The facts are shown in Table 52, below, and Figure 9, page 136. The finer movements of finger and wrist begin

TABLE 52

Age changes in speed of voluntary movement: Average number of taps per second made in 5 seconds by movement of shoulder, elbow, wrist, and finger by men and women.

AGE	SHOULDER	ELBOW	WRIST	FINGER
17–19	5.87	6.77	6.67	6.32
20–24	5.90	6.60	6.47	5.95
25–29	5.92	6.64	6.43	5.67
30–34	5.92	6.80	6.37	5.63
34–39	5.79	6.51	6.31	5.55
40–44	5.91	6.53	6.36	5.50
45–49	5.73	6.42	6.21	5.50
50–54	5.64	6.34	6.04	5.33
55–59	5.42	6.04	5.79	5.18
60–64	5.33	5.95	5.66	5.11
65–69	5.13	5.83	5.71	4.99
70–74	4.80	5.41	5.11	4.64
75–79	4.36	5.41	4.80	4.68

their decline somewhat earlier than the coarser movements of elbow and shoulder. From fifty on, all take about the same course.

The score at age 40 to 44 is 92.4, 98.3, 99.0, and 100 per

cent of that at age 20 to 24 for finger, wrist, elbow and shoulder respectively, giving an average drop of 2½%.

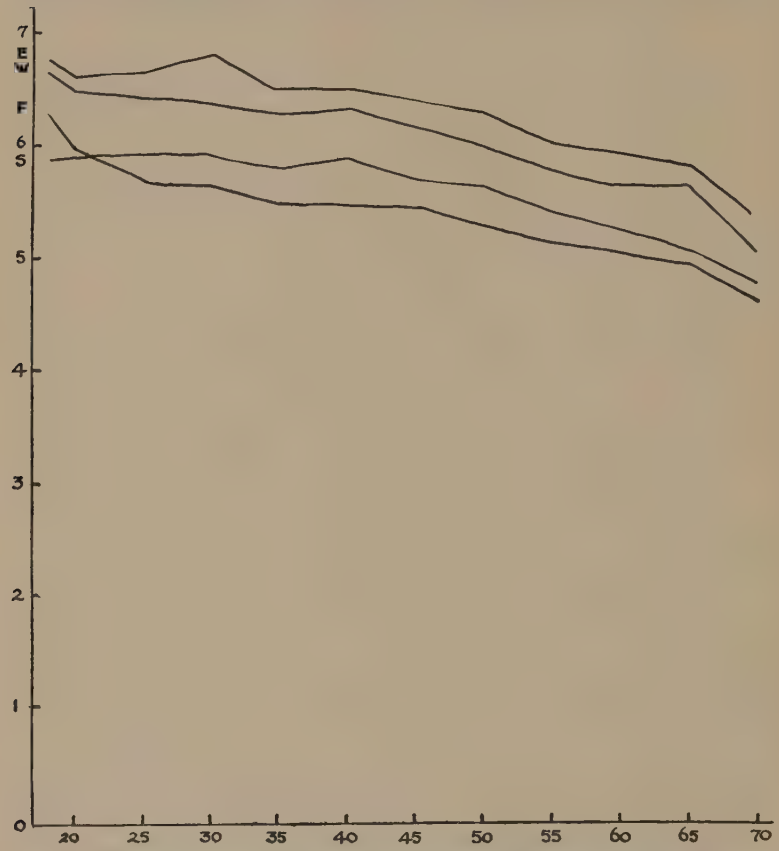


Fig. 9. Age Changes in Speed of Voluntary Movement; the Rate of Tapping at Ages 17–19, 20–24, 25–29, 30–34, etc. *E*, *F*, *S*, and *W* Refer to Elbow, Finger, Wrist and Shoulder Movements.

The drop in twenty years is less than the average gain for one year from age 10 to age 15.[1]

[1] Computed from Bryan, "Voluntary Motor Ability," *American Journal of Psychology*, Volume V, pages 123–204.

These age changes may themselves be due in part to lack of practice in pulling, gripping, etc. Let us, however, assume that practice and disuse from 22½ to 42½ balance in these functions, so that the records of Tables 51 and 52 represent the decline due to inner degeneration. If the inner degeneration of ability to learn follows anything like the same course as these functions of strength, speed, and sensory discrimination, it cannot account for more than a small fraction of the drop of 13 to 15 per cent from age twenty-two to forty-two. It may, of course, be that the age drop of inner degeneration of ability to learn is five times as fast as that of speed or sensory discrimination, but the writer cannot find any impressive evidence that this is so.

Under the auspices of the Carnegie Corporation, Dr. Calvin Stone is making a study of the relation of ability to learn to age in the case of the white rat, which will provide facts of great importance and be free from most of the complexities which attach to our parallel study in the case of man. Dr. Stone's work will not be completed until July, 1928, but we have had the privilege of studying some of his results obtained to date (September, 1927).

In the case of his rats the age comparisons are always between two groups made up of identical ancestry by selection of litter mates in pairs, one of each pair being assigned to each group, to secure substantial equality of general intelligence. Both groups had the same amounts of fore exercise with the maze (five trials) before the experimental training, which was thirty trials, one a day for thirty days. So far as we know, there was nothing in the general life of the rats to make one who had lived eighteen months differ from one who had lived two months, in respect of ability to learn a maze. We are aware of no differences between age groups in capacity, training (special or general) or disuse. All the apparent factors

that could cause differences in their learning are the growth and decay of the ability with age, and possibly variations in the strength of the motives (chiefly hunger) which led the rats to reduce the time and errors in traversing the maze to the food.

We have computed from Dr. Stone's records the number of trials required to progress from 6.5 errors to 2.0 errors, in the case of each group. We also report the average and median time and errors in the last five trials of the thirty. These facts appear in Table 53, page 139. The data used are reported in Appendix XIV.

In examining Table 53 and Appendix XIV, 50 days, 75 days, 6 months, and 18 months may be thought of as roughly corresponding to 14 years, 18 years, 22 years, and 42 years in man. Dr. Stone writes:

> The average age in which sexual activity (first oestrus and first copulation for females and males respectively) is approximately 50 days for optimum conditions of nutrition. The average age at which males and females are fertile and beget young under optimum conditions is between 70 and 85 days according to conditions under which breeding tests are made. (Isolate a pair and it usually approaches the lower age; leave several together (5 to 8) in a cage and the upper age is approached). I think that 80 days would be about right for our colony *on the side of fertility;* 50 days for *first sexual activity.*
>
> According to recent figures from Slonaker, Stanford University, rats living in isolation die of old age between the age limits of approximately 750 and 1,100 days. His average falls roughly at 900 days. One animal is still living at 1,300 days.
>
> Under ordinary cage conditions such as we have he thinks that the life span is shorter than when they are reared in isolation and in better hygenic conditions than colony cages afford. This average age is probably *about 800 days,* in his opinion. That would be about right for our colony.

Table 53 shows that there is no loss in ability to learn from 3 months to 12 months, and little or none from 12 months to 18.

TABLE 53

The relation of age to ability to learn in the white rat.
From unpublished data of Stone.

PAIRED GROUPS		N	NUMBER OF TRIALS REQUIRED TO PROGRESS FROM 6.5 ERRORS TO 2.0 ERRORS *	AVERAGE FOR LAST 5 TRIALS	
				Seconds	Errors
I	25 days	47	7− (2+ to 9)	26.1	0.9
	50 days	54	7.5 (1 to 8.5)	16.0	0.8
II	100 days	21	24 (5− to 29)	22.3	2.2
	150 days	16	18 (5.5 to 23.5)	18.7	1.7
III	75 days	24	24 (4 to 28)	26.1	2.0
	10 months	25	19 (2.5 to 21.5)	14.6	1.7
IV	6 months	29	14 (3 to 17)	11.9	1.2
	12 months	25	13.5− (3.5+ to 17−)	11.6	.9
V	12 months	35	21.5 (4 to 25.5)	21.4	1.8
	18 months	25	24.0+ (2− to 26−)	36.3 †	1.9
VI	9 months	25	13.5 (5.5 to 19+)	12.2	1.4
	18 months	17	12 (1.5 to 12.5)	9.0	.6

* The points at which 6.5 and 2.0 were attained were computed as follows: The first 6.5 or a 2.0 preceded by scores averaging higher and followed by two successive scores whose average was lower was taken, if there was such. If there was not, the midpoint of the first sequence of scores averaging between 6.3 and 6.7 or 1.9 and 2.1 and followed by a sequence of two averaging respectively lower than 6.5 or 2.0 was taken.

† This 36.3 is an average of 30.4, 21.6, 16.1, 94.4, and 19.1. The median 21.6, is probably a better index of the status of the learning.

The fact appears equally clear in the comparison of learning curves made by combining (with equal weights) the scores for the four groups of rats aged 75 days, 100 days, 150 days and 6 months, and by combining (with equal weights) the scores for the four groups of rats aged 10, 12, 12, and 18 months. Fig. 10, page 140, shows the time curves and Fig. 11, page 141, the error curves. Assuming, as is reasonable, that the average general intelligence is alike for these two large groups of rats tested at an

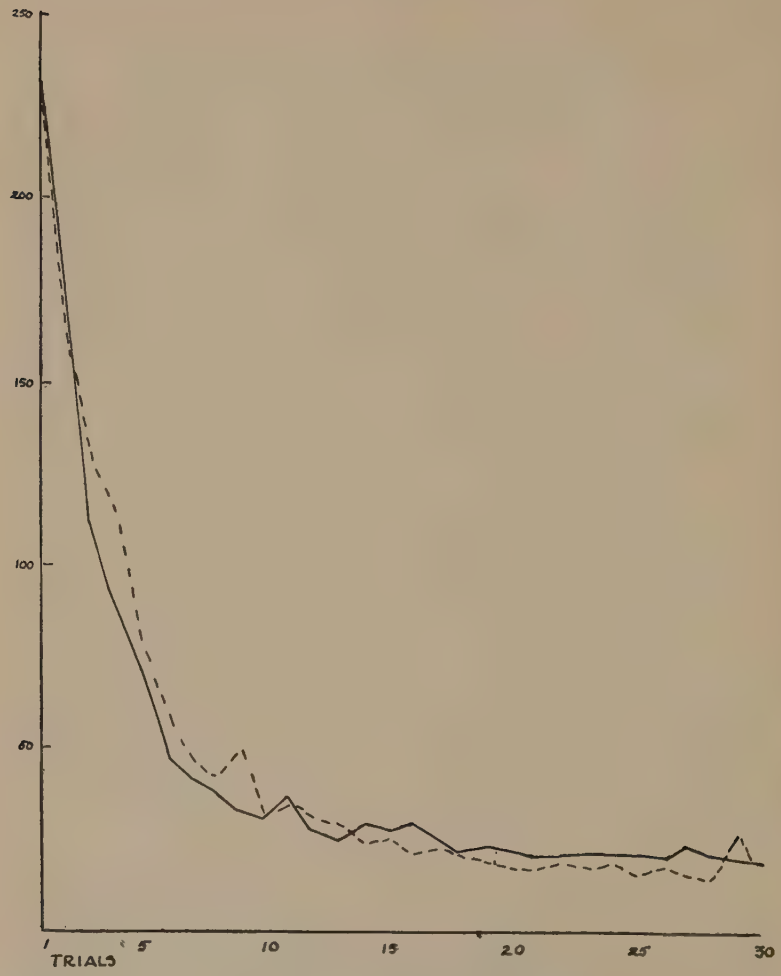


FIG. 10. AVERAGE TIME REQUIRED IN SUCCESSIVE TRIALS WITH THE MAZE BY RATS AGED 75 DAYS, 100 DAYS, 150 DAYS, AND 6 MONTHS (CONTINUOUS LINE) AND BY RATS AGED 10, 12, 12, AND 18 MONTHS (DASH LINE).

average age of 4 months and 13 months, we must conclude that learning at age 13 months is practically indistinguishable from learning at 4 months.

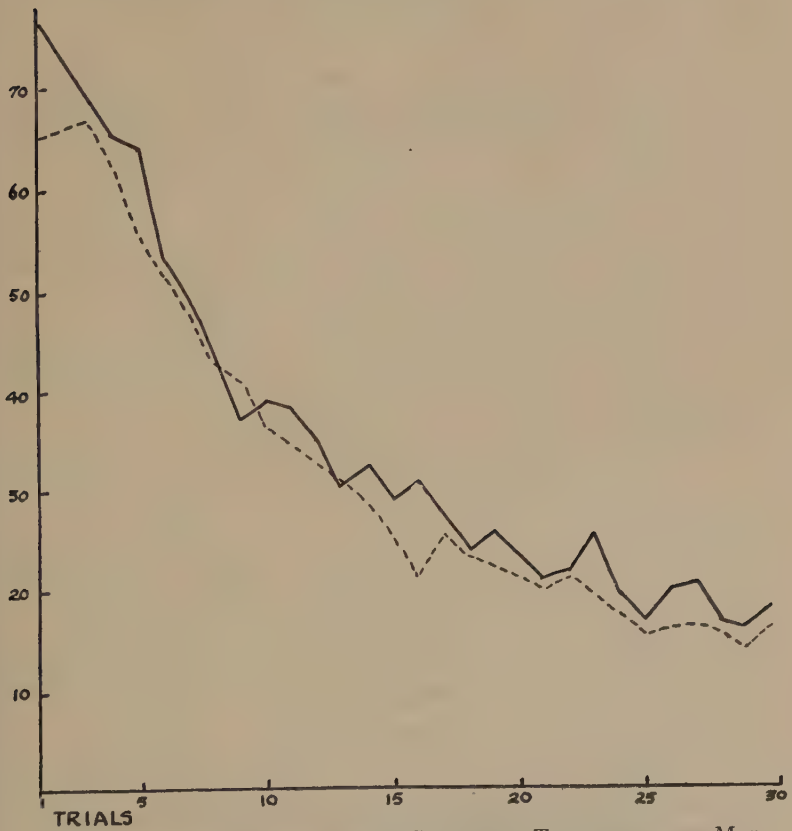


FIG. 11. AVERAGE ERRORS MADE IN SUCCESSIVE TRIALS WITH THE MAZE BY RATS AGED 75 DAYS, 100 DAYS, 150 DAYS, AND 6 MONTHS (CONTINUOUS LINE) AND BY RATS AGED 10, 12, 12, AND 18 MONTHS (DASH LINE).

The rapid learning of the rats at 25 days and the specially rapid learning of the rats at 50 days may possibly be truly representative of their ages; but this seems

unlikely in view of the facts for the 75 days group. It is more probably due to greater hunger in these younger rats. Dr. Stone is conducting experiments to clear the matter up. Among these experiments are a series with rats of 18 months concerning which Dr. Stone writes as follows:

> About a half month before they came up for training I began to deprive them of food systematically so that by the time they came to the preliminary training they had lost a great deal of the fat pads and were in a condition of mild chronic inanition. Then when we put them on the training we cut down their daily allowance so that they continued to lose weight at a slow rate throughout the experiment. The result of this rather drastic deprivation of food was a steadier performance for all and a somewhat faster running rate for all. In addition to eliminating the sporadic exploratory tendency in the maze, which reduces the number of errors, I believe that they cut their entrances to blinds at difficult points of the maze somewhat faster than the other adults. In fact their curve is even slightly better for errors than that for the 25 and 50 day groups.

If we combine the curves of learning for 25 days, 50 days, 75 days, 100 days, 150 days, and 6 months on the one hand and those for 9, 10, 12, 12, 18, and 18 months on the other, we have substantially equal learning, as shown in Figs. 12, page 143, and 13, page 144, in spite of the possible advantage for the younger group in the way of motive. The old rats do not progress quite so rapidly in the early trials but they make a greater gain in the later trials and have better scores at the end.

This evidence against the existence of any considerable postadolescent inner degeneration in learning power as a general mammalian trait should be checked by similar studies with other mammals. As it stands, it weakens the probability that the drop found in man is due to inner degeneration.

The details of our actual results with university students, prisoners, evening high-school students, and students in secretarial schools are hard to explain by inner degenera-

tion, or disuse, or any combination of them. No one simple cause will account satisfactorily for the facts (1) that the drop with age was so much greater in the

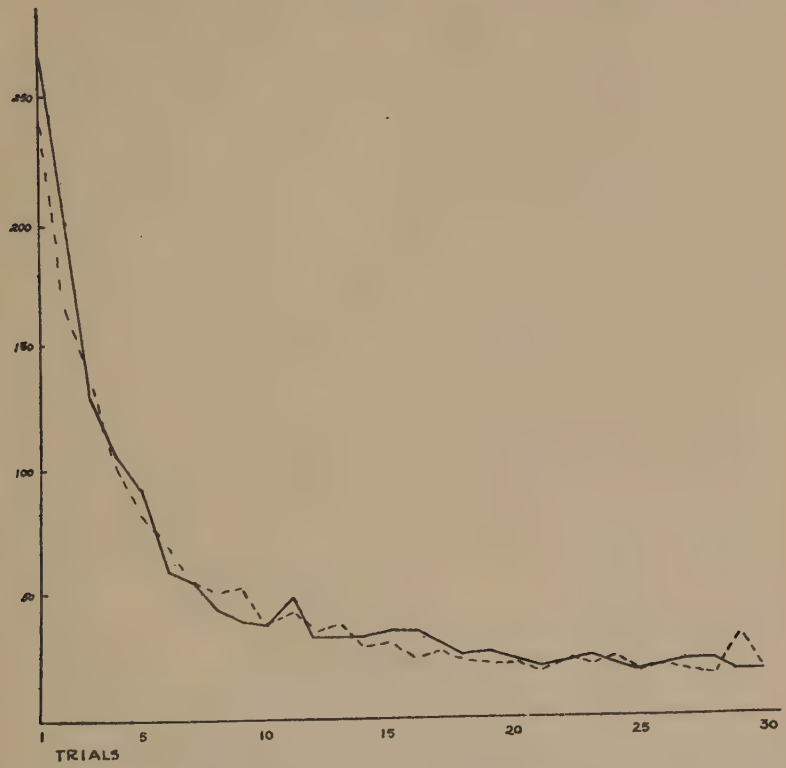


FIG. 12. AVERAGE TIME CURVE FOR ALL YOUNG RATS (6 MONTHS OR LESS) AND ALL OLD RATS (9, 10, 12, 12, 18 AND 18 MONTHS). - - - - = YOUNGER. ——— = OLDER.

university students than in the prisoners or evening high-school students, (2) that the university students showed no drop in the case of grades in subjects studied, and (3) that they showed so much greater drop in drawing lines or connecting numbers with syllables than in Esperanto.

FIG. 13. AVERAGE ERROR CURVE FOR ALL YOUNG RATS (6 MONTHS OR LESS) AND ALL OLD RATS (9, 10, 12, 12, 18 AND 18 MONTHS). - - - - = YOUNGER. ——— = OLDER.

An explanation by disuse fits the difference noted in (1) fairly well. The large declines were in the university students. They build up by practice in school and college days an ability to learn which declines greatly in twenty years of relatively little use, so that when a man of forty stops the practical work of teaching to study for a year, his ability to learn is far behind that of the twenty-five-year-old who represents what he himself was twenty years before. The adults in evening high school (grade 9) had spent much less time in learning when young and so had added little to their natural ability to learn such things as high-school subjects. They had less to lose by the years of disuse and did lose less. The prisoners, who had spent almost no time in learning such things when young and had still less to lose from disuse, showed still smaller declines with age.

But disuse does not explain (2) and (3) above at all satisfactorily. By disuse alone, the university group should have fallen off notably in grades attained in university courses, and more in Esperanto than in learning a code or to connect numbers with nonsense syllables. We have to invoke subsidiary causes such as differences in self-consciousness, or in interest, or in time spent, and an alleged power of the months of study to reinstate the ability to learn the subjects studied, but not to reinstate the ability to learn new motor skills. What the older persons could not learn was especially to draw lines of prescribed lengths and to learn a code and to connect numbers with syllables. These forms of learning had not been specially practiced in college days and left without practice since then.

It is as hard to fit the detailed facts to inner degeneration as a cause without invoking subsidiary influences. The difference between the university students and the prisoners is the greatest difficulty. Our detailed facts do not show any clear superiority of either hypothesis.

On the whole, the facts about age changes in general, age changes in animal learning, and our results with man justify a rather vigorous skepticism concerning inner degeneration as the *sole* cause of the drop in learning power from twenty-two to forty-five. Disuse has substantial claims to some recognition. The decline is then not only small in amount; it is also probably in part avoidable by the simple expedient of continuing to learn. Adult learning is itself probably a partial preventive or cure for adult inability to learn.

The Causation of the Age Changes in Amount Learned

On the average, at the present time, individuals probably learn much less per year from twenty-five to forty-five than they did from five to twenty-five. The magnitude of the decrease is, however, exaggerated in the common view which represents the child and adolescent as incessantly and actively seeking for new impressions, ideas, and skills, and rapidly absorbing the traditions, manners, and habits of those with whom he is in social contact, and represents the adult as remaining almost *in statu quo*.

Children and adolescents, in fact, spend a very large part of their time in routine performances which are uneducative — in sleep, in dressing and undressing, in eating, in playing the same plays no better than before; in telling what they and others have done and where they have been, without any linguistic improvement; in reading the comic page of the newspaper and stories which are for the most part only temporary stimulations, distractions, and reliefs; in routine acts of helpfulness around the house or farm; and in watching familiar occurrences without any instructive reflections concerning them. The learning of adults is rarely *nil*. At the least, they learn a host of concrete particulars; new names and

faces, new items about automobiles, baseball players, movie stars; what "they are wearing" this year, and the like; some new skills as their jobs change and new recreations attract them; and a few general ideas about the war, prohibition, socialism, or religion. At the most, as in the case of the scientific investigator or historical scholar, paid for learning in money or esteem or both, they may learn much more than they did in childhood.

The decrease in learning, which does, on the average, occur, may be explained by various combinations of the four factors, general health and energy, ability to learn, interest in learning, and opportunity. A decline in general health is probably of great significance in respect of the decline in learning at very late ages (say sixty-five to eighty-five), but is of small consequence for changes from the score of years around fifteen to the score around thirty-five.

We have shown that the decline from the acme of ability to learn (located probably at some point between twenty and twenty-five) to about forty-two is only about 13 to 15 per cent for a representative group of abilities; and that ages 25 to 45 are superior to childhood, and equal or superior to early adolescence (14 to 18), in general ability to learn. In the rest of this chapter our task is to consider those forces of interest and opportunity which would cause changes with age in learning, even if ability to learn showed no change.

Changes in Opportunities for Learning Which Would Decrease the Amount of Learning if the Ability to Learn and Interest in Learning Did Not Decrease

In general, a person has less time to learn in from 25 to 45 than from 5 to 25. More time is required of him by law and by custom for productive or household labor.

The child is specifically protected from productive labor in order that he may grow and learn by school and play. This protection indirectly requires that his parents work more. The adolescent's status varies from that of a child free to give all his day to learning to that of an adult whose day is all needed for other duties than self improvement, according to the customs of his social class, the assumption of parenthood, and other conditions.

In general, there is much less economic and social pressure toward learning in the later score of years. The child is paid for learning, not in money wages at the time, but in freedom to play when his daily stint of learning is achieved, in the approval of teacher and some classmates, and, in adolescent years, by the future financial hopes[1] and immediate present social prestige which attach to progress in high school and college. Modern families and communities force young people to learn in ways that range from obvious rewards and punishments to very subtle but powerful manifestations of opinion and fashion. At thirty very little of this pressure to learn acts. In nine cases out of ten, the business which employs a man would not find his services more valuable if he learned Latin or calculus or medieval history or to play the violin. There are only a very few sorts of learning which will benefit him in his present employment. To study at great length with the hope of then bettering himself by a radical change of employment is obviously risky. In nine cases out of ten the married woman finds, or thinks she finds, that success in getting herself and her children taken care of depends very little on any learning outside a very narrow field.

If both young and old were sent to school five hours a day and worked in our present industrial system five hours a day, and if the economic and social pressure were

[1] The extent to which these hopes are justifiable does not here concern us.

equalized, there would surely be a notable reduction in the disparity in learning. In the narrow fields referred to above which give, or promise to give, advantage in wages or prestige, adults *do* pay their good money as well as their time for learning.

These two factors, time for learning and outside pressure, economic or social, are perhaps too obvious to have been mentioned. The one to be mentioned next is so far from obvious that it has received very little attention. It is the time and attention requirement for relearning or not forgetting what has been learned. Information and skills that have been acquired are not at all comparable to money that is put into a perfectly safe bank. They are rather like capital in the form of a building or ship or freight car, that should have an annual charge for depreciation or for preventing it by repairs. All, or nearly all, learning vanishes if not used. What a person now knows and can do has been kept alive by relearning, either open relearning or hidden relearning in the form of such practice as prevents the knowledge or skill from ever falling below par and needing an obvious review. If a child of five lived an average life except that from five on he must retain everything that he learned, he would, from twenty-five on, be hard put to it to hold his own if he never learned one new thing. We all forget most of what we learn, some of it in a few minutes, much of it over night, and more month by month.

Much of what we learn nobody need wish to retain; but a good deal of it is needed, and preventive practice or relearning for this useful fraction takes time. For example, the average pupil in grade eight knows after a fashion the meanings of about ten thousand English words. Some of these would not be lost by disuse in a decade, but some would go if not rehearsed within a year. When a man whose profession is scholarship studies, his study not only adds to his knowledge and insight but provides a continual

review of what he already knows, and a means of exercising and maintaining the powers of insight which he already possesses. Keeping up with one's profession consists in not losing knowledge and skill and power as well as in gaining more. For some factory workers and tradesmen the amount of time required for relearning (or review to prevent the necessity for it) may be a small, even an insignificant quantity. And in general it may not be a large factor. But it is a real one. And it is unavoidable. It is also probably general, applying not only to knowledge and skill, but also to all those subtle results of learning which we call attitudes, powers, tendencies, or traits of personality. There is a natural status, the product of unlearned or original tendencies, from which we change by learning and to which we relapse unless the results of learning are maintained by relearning or some equivalent of it.

Changes in Interest in Learning Which Would Decrease the Amount of Learning if the Ability to Learn Did Not Decrease

By the age of twenty-five most persons have, within certain limitations, learned a great part of what they wish to learn. As children and adolescents they have seen others manifesting certain knowledge and skills and powers, and have felt cravings for the possession of these — desires to swim, dance, skate, or drive a car, to have good manners, to understand or pronounce certain words, to know enough of a trade or profession to be able (other things being equal) to earn a living by it, and the like. One by one they have learned these things, in so far as they were willing to give the time and effort needed, and were not prevented by untoward circumstances. This same course of events would in large measure have occurred with reading, writing, simple arithmetic, knowledge of commonly-referred-to facts of geography, history, and

other features of school learning, except for the fact that these wants are supplied before they are felt.

As a result of the individual's learning what he wishes to learn, and of the home and school's having him learn, before he wished to learn them, things which he would otherwise wish later to learn, the ordinary American of today has at twenty-five in large measure supplied his demand for learning. He has had his try at a fairly wide sampling and has either learned the accomplishment in question or been unwilling to pay the price in time and effort. If the offerings of all the schools in the world were available for him in a free evening school beside his home, he would be unmoved by most of them, either because he does not and never did want them, or because he tried learning things like them and did not find the game worth the candle, or because he has already as much of them as he wants. He may very likely offer as a good reason for declining some opportunity that he has not enough time, or is too tired, or is too old to learn, when the real effective reason is that his genuine desires for learning have already been satisfied. A few individuals crave so many sorts of learning that life is not long enough to satisfy them; some learn all they want to learn by the early teens; the ordinary man or woman, under present conditions of life in America, has supplied most of his intrinsic natural demand by the early twenties. Thereafter he restricts learning to matters which are to his economic advantage, or which meet desires evoked by new situations, like the emergency of war or the invention of the radio, or which gratify desires which were thwarted in youth. In the competition with other ways of spending time, learning weakens relatively year by year as we satisfy one craving after another of those which need learning to satisfy them.

Curiosity and the love of mental life for its own sake — of experiencing, thinking, and learning rather than being

in a state of mental torpor — may weaken from the teens to the forties as they seem to do in later senility. James was sure that they did. We feel much less sure, for several reasons. First of all, they have stronger competition as age increases, first from sex and later from sex and parental interests. In the second place, the alleged decline in the actual manifestations of curiosity and thought for thought's sake is likely to be exaggerated. Fathers are often glad to play with the toys, and mothers to look at the picture books, which they buy for their children. Adults seem to enjoy travel and the movies nearly or quite as much as children do. The investigations, dramatizations, and imaginative play of childhood are in some measure matched by the magazine reading of their parents.

In the third place, the stimuli which evoke curious investigating behavior and mental play in the young to some extent give out. Just as the adult may learn less because he has learned so much of what he wants to learn, so the adult may show less curiosity because the sights and sounds and machines and toys which entice young children have already enticed him, and have been investigated and assimilated. Show him new machines and toys, say an automatic oil furnace and a novel cigar lighter, and he may show full curiosity.

Even if curiosity and the love of mental activity do not decline in absolute amount we may expect them to be satisfied to a certain extent in adult life by what happens to the individual in the course of productive labor. The work of all professions, much of trade and selling, and much of housework, offer a succession of novelties, problems, and emergencies which help to exercise and satisfy these cravings. The unsystematic and temporary problems of business are as truly food for the interest in mental activity as the systematic and continuous study of economics.

The interest in learning probably often suffers relatively in adult years because the adult tries to speed up the learning and so undergoes more and greater strains and thwartings than does the more leisurely learning of childhood and youth. A child, for example, spends perhaps five thousand hours in learning to understand and use oral English. If as an adult he tries to learn to understand and speak German or Russian, he probably tries to proceed at five times as fast a rate. A college student, highly selected for intelligence, spends perhaps three hundred hours in acquiring a few very simple concepts and principles about the production, distribution, and consumption of wealth. If he takes up economics as an adult, he allows less than half as much time for a similar achievement. Common practice is perversely inconsistent in this matter. It assumes that the ability to learn declines in adult years, but assigns longer or harder tasks per unit of time available for learning.

CHAPTER XII

Age and Qualitative Differences in Learning

[In this chapter we shall report facts concerning qualitative differences between the learning of adults and the learning of children and young adolescents, and between the learning of adults 25 to 45 and that of adults 20 to 25.]

Intelligence

One of the chief differences which school practice finds important to consider when choosing methods of instruction is the difference in intelligence, or brightness, or whatever we choose to call the ability measured by such tests as the Stanford-Binet, Terman, National Intelligence, and the like. So we ask first how adults differ from children and young adolescents, and how older adults differ from younger in this respect.

With ordinary conditions of present-day environment in America a person's score in such tests improves up to a time variously estimated from 14 to 20, the later estimates being in our opinion nearer the truth. Adults may be expected to learn harder things than they could have done in the years from six to sixteen and to learn the same things in ways requiring greater powers of abstraction and reasoning. They can for example understand general rules in language, grammar, or spelling which would have been incomprehensible to them at the age of ten. These facts are well known, and allowance (perhaps too much allowance) is made for them in the textbooks and methods of instruction used in teaching adults.

Almost nothing has been known concerning the curve of intelligence in relation to age from twenty on to forty-five. In the Army Tests the older men did less well, but there is good reason to suppose that they were a selection of the relatively less intelligent. In the infantry, especially, the old sergeants of the regular army who were made captains and lieutenants would be duller than the young college and business men from the officers' training camps. The authors of the Report on the Army Tests say:

> The dependence of intelligence upon age of adults is a theoretical problem of great interest upon which, however, the results of psychological examining in the Army can throw little light. It is possible to draw up tables of intelligence ratings and age as reported on the examination blank, to compute the regressions, and thus to determine the relation between age of officers or of men in the Army and their intelligence; but with the relationship once determined there is still no way of saying to what extent it reflects a fundamental dependence of intelligence upon age or to what extent it may be caused by the selective processes always at work in separating the Army from the total population of the country. If among the older men only the more intelligent sought to be officers or were so well established in life that they could afford to be officers, or if, on the contrary, among the older men only the poorer professional men could leave their businesses to enter the Army or were industrially unessential so that they were forced into the Army, then we should find a very positive relation of the one sort or the other between intelligence and age in the Army — a relation which would arise entirely as a result of selection in the Army and be utterly factitious as an indicator of a dependence of intelligence on adult age in general. Similar selective factors might work equally well in the case of drafted men. (Yerkes, '20, p. 813)

Probably the safest comparison is among medical officers; but even here it is probable that the older men who were physicians in the regular army and volunteers from the medical profession were on the whole relatively a lower sampling of old medical men than the young doctors of draft age were of young medical men. The facts for the medical officers tested are shown in Fig. 14, page 156.

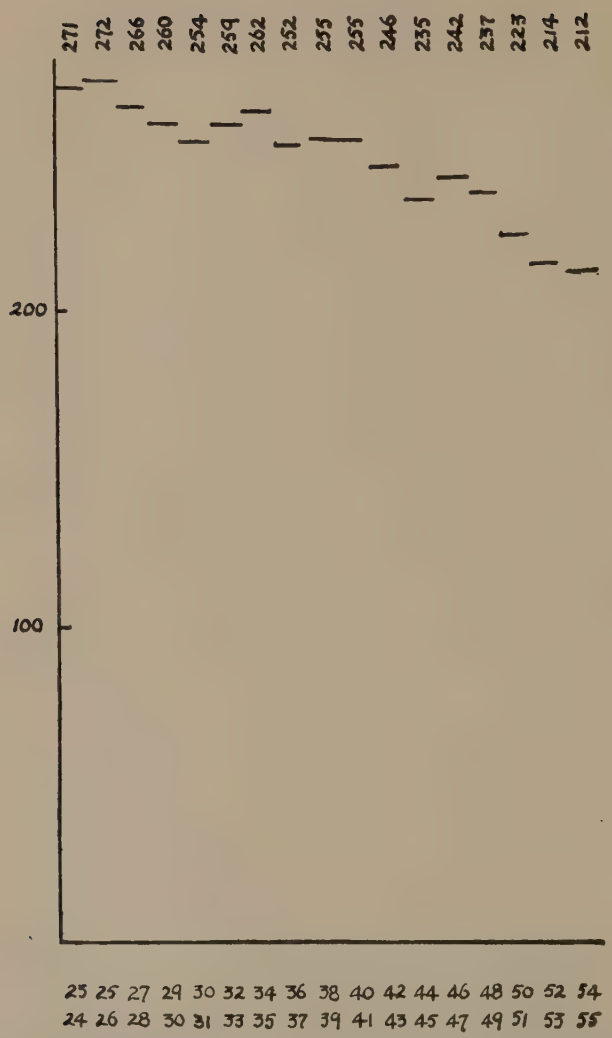


FIG. 14. AVERAGE SCORES IN EXAMINATION A (AN EARLY FORM OF *Army Alpha*) OF MEDICAL OFFICERS OF AGE 23 TO 55.

Hollingworth ('27, p. 310) found scores in a combination of sentence completion, naming the opposites of words, word building, and memory span for digits, as follows: 59 for ages slightly under 20, 59.5 for 20 to 24, 58 for 25 to 29, 60 for 30 to 34, and 64 for 35 to 44.

Through the kindness of Miss Lycia Martin, Mr. Wm. P. Reed, Dr. T. W. H. Irion, Dr. M. E. Haggerty, Dr. W. B. Pillsbury, and Dr. G. M. Ruch we have secured records in two tests with *Army Alpha* made from five to nine years apart on 58 individuals of the ages shown below. Form 7 was used in all the late tests. Which forms were used in the early tests we had no means of knowing. Eleven individuals aged 16 to 19 at the first test, and averaging 147 in it, gained 14.0 on the average; 31 individuals aged 20 to 24 at the first test, and averaging 157 in it, gained 14.1; 11 individuals aged 25 to 29 at the first test and averaging 158 in it, gained 8.8; 5 individuals, aged 30 to 45 (averaging 37) at the first test and averaging 169 in it, gained 8.4.[1] Some deduction should be made from these gains for the practice effect of a second test over a first, presumably about 14. Whatever allowance is made, the older ages lose only a little more (or gain only a little less), namely, 5 or 6 *Alpha* points on 160 or 170.

The most illuminating information on age differences in scores in intelligence tests will be found in a report soon to be made by Dr. Harold B. Jones of his study of the entire population of a rural community. By his courtesy we are able to quote the essential facts here in Table 54. Selective factors are here substantially the same for young and old, so that the scores of the old may be compared with the scores of the young with little or no reservation. The median *Alpha* score rises to an acme of 93 at 17 to 21 and falls to 84 for the years 35 to 50.

The score in *Alpha* is, of course, not a perfect measure of intelligence, and it may not be equally fair to all ages. In

[1] The probable errors of the average gains are 2.7, 1.9, 2.1, and 3.3.

particular, its linguistic and arithmetical items may favor those who are not long out of school. If we take the results at their face value, our error, if any, will probably be to penalize age. With this in mind we may think of a

TABLE 54

Scores in *Army Alpha* made by the population of a community, classified by age. From data of Harold B. Jones.

ALPHA SCORE	FREQUENCIES AT AGES											
	11 and 12	13 and 14	15 and 16	17 and 18	19 to 21	22 to 24	25 to 29	30 to 34	35 to 39	40 to 44	45 to 49	50 to 54
0– 9	4	1					1	1		1		
10– 19	2	5	2			1	3	4	3	6	4	1
20– 29	16	6	5	1	1	1	1	5	7	3	2	4
30– 39	25	8	8	4	6	3	2	6	9	3	5	6
40– 49	14	14	6	8	1	4	3	7	6	5	4	4
50– 59	21	21	7	5	11	2	9	7	10	9	10	6
60– 69	17	15	11	12	7	3	7	8	4	6	8	6
70– 79	9	12	13	6	9	6	13	11	5	4	5	4
80– 89	10	21	18	10	5	2	10	11	11	10	7	2
90– 99	2	8	15	9	9	3	12	2	7	9	5	2
100–109	3	8	8	3	4	3	6	5	5	5	3	3
110–119	2	6	10	11	6	4	8	7	6	6	5	3
120–129		2	9	9	7	4	1	7	8	4	1	7
130–139		2	11	4	1	3	1	9	7	7	2	2
140–149			7	4	6		5	4	4	6	5	1
150–159			5	6	2	3	3	3	1	4	1	2
160–169			2	2	2	1	2	2		3	2	2
170–179				2	6		2	4	2	3		1
180–189				1	3				1	1		
190–199						1	1	1				
200–209					2							
No. . .	125	129	137	98	83	44	90	104	96	95	69	56
Median .	51	66	89	93	94	90	84	83	84	90	73	73

person as losing in general intelligence from twenty-two to forty-two about as much as he gains in a year from twelve to sixteen.

We may then, in general plans for adult education, figure on a slight age loss in intelligence from twenty-two

to forty-two, such as was found in the case of strength, speed, and skill. In any particular group it will be a simple matter to test each individual in respect of intelligence score. Individual differences amongst those of the same age will enormously outweigh differences between ages in adult intelligence.

Memory

Adults perhaps complain oftener concerning their ability to memorize than concerning any other, and popular pedagogy has assumed that this ability has its acme in childhood and falls off during adolescence. Fortunately, memory up to about sixteen has been the subject of several elaborate investigations and there is a substantial body of fact concerning later years.

It is useful to consider memorizing in three ways. *First*, we have what is called by psychologists "immediate" or "temporary" memory, meaning the ability to grasp and hold in mind for a few seconds or minutes. This is measured by the amount so remembered per unit of time or of repetitions devoted to study, or inversely by the amount of time or number of repetitions required to bring the memory of certain material to a status such that it can be repeated without error, or to a defined approximation thereto. *Second*, we have long-term or permanent memory, meaning the ability to hold in mind for days, weeks, months, or years. This is measured by the amount so remembered per unit of time or of repetitions devoted to the original study, or by the total times of study (original and later) required to bring the memory of the material to a certain status at the later date. *Third*, we have memory as the difference between what one remembered soon after the period of study and what one remembers at some later period. This may be measured inversely by the difference in the two amounts, or by the

saving in time or repetitions required to relearn to the same degree of mastery as was shown soon after the period of study.

The experiments on immediate memory are substantially unanimous in reporting that adults so memorize much better than young children do. There is some ground for suspicion that adults in universities were compared with ordinary children in some of these experiments and that if only adults and children of equal intellectual level had been used, the superiority of the adults would have been much less. Even with full allowance for this correction, however, the adults would probably still lead. There probably is an improvement up to about 15 and a fairly stable condition from then to 40 or later.[1]

The experiments on memory over longer intervals are fewer and less conclusive. The permanent effect of a given time spent in memorizing certain material probably shows less superiority of adults than the temporary effect. The best available data are those of Henderson ('03) and Lyon ('16). Henderson tested the memory for the contents of passages (1) after a few minutes, (2) after two days, and (3) after four weeks. His data permit comparisons of adults in summer session with pupils in grade 7 or with pupils 15 and 16 years old in grades 6 and 7, or with pupils of 14 in grades 5, 6, and 7, and college students with high school students in the first half of grade 9, in the last half of grade 10 and in the last half of grade 12, and of graduate students with college students. The older group is also in each case probably a higher selection as regards intelligence.

The superiorities of the older and more select groups in the three tests are shown in Table 55, page 161. The four-week memories here show the same differences as the immediate memories.

[1] The chief experiments have been those of Shaw ('96), Henderson ('03), Pöhlmann ('06), Radossawljewitch ('07), and Meumann ('08).

TABLE 55 *

Superiorities of older and more highly selected groups in amount remembered (of a passage of prose, scored by ideas remembered) after (I) a few minutes, (II) two days, and (III) four weeks. *A*, *B*, and *C* refer to different passages, so that the scores are comparable only within *A*, or within *B*, or within *C*

	I		II		III	
A. S.S. to 7B	3.5	53.0 to 49.5	1.8	48.3 to 46.5	3.9	45.8 to 41.9
" " 15, 16	1.5	" 51.5	−.5	" 48.8	1.0	" 44.8
" " 14	7.0	" 46.	4.3	" 44.	6.8	" 39.
B. Coll. to 9 gr.	11.2	48.0 to 36.8	5.5	36.5 to 31.0	11.7	34.5 to 22.8
C. Grad. to Coll.	5.2	42.2 to 37.0	7.6	34.6 to 27.0	5.4	29.5 to 24.1
Total for A. S.S.	12.0		5.6		11.7	
Total for others	16.4		13.1		17.1	

* Compiled from data of Henderson, '03, pp. 34–40.

Lyon found (as shown in Table 56, page 162) that 12 clerks and business men of ages around 30 averaged a trifle less time in both learning and relearning than did 60 high school pupils of ages around 17. He also found that 24 asylum attendants of ages around 25 made an average almost identical with that of 40 grammar school girls around 14. The foregoing are for permanence over ten weeks in the case of words, prose and poetry, and one week in the case of digits and nonsense-syllables. He obtained results also by which inmates of a state reformatory, a workhouse, and a prison of ages around 20, 26, and 34 respectively, may be compared. The number of individuals was 24, 12, and 24 respectively. The memory interval here was three weeks. The young reformatory group was much the best, being in fact better than college seniors.[1] The old prison group was next best.

[1] Dr. Lyon's results for this group are so extraordinary that they should sometime be checked by additional observations.

TABLE 56

The average time (in minutes) for learning and relearning (after 1 week for digits and nonsense syllables, and after 10 weeks for words, prose and poetry). After Lyon, '16, p. 48.

	MODAL AGE	LEARNING	RELEARNING
40 grammar school girls	14	16.7	6.0
24 trade school boys	16	15.3	5.8
60 high school pupils, boys and girls	17	17.0	5.9
132 normal school students, girls	21	14.5	5.2
24 asylum attendants, both sexes	25	16.2	6.2
12 clerks and business men	30	16.1	5.8
16 graduate students and professors	32	14.0	5.0

TABLE 56 A

Same as Table 56 (except that the interval was 3 weeks for all materials) After Lyon, '16, p. 49.

	MODAL AGE	LEARNING	RELEARNING
24 State reformatory inmates, men	20	9.2	3.0
32 college seniors, men	22	11.0	3.9
14 college seniors, women	22	9.4	3.4
12 workhouse inmates, men	26	13.2	5.0
24 prison inmates, men	34	12.1	4.6

In the third aspect of memory, that is, the difference between what one has at the end of the period and what remains some weeks or months later, the majority of those who have compared old with young regard the young as superior to the old. This is probably correct, though there is some ground for suspicion that part of the superiority shown in the experimental results is spurious. If at the original learning the person "overlearns," that is, spends more time than he needs barely to be able to repeat the material after a few seconds, he will seem to be poorer than he really is in the original learning, and to be better than he really is in sheer retention. There is some reason

to believe that children are more prone to do this than adults. It may be noted that whatever allowance is thus subtracted from juvenile memory of type III should be added to juvenile memory of type I.

The reports of differences in long time retentiveness of what one had at the close of study often confuse the question by expressing the difference between the amount retained for, say, 1 minute and the amount retained for, say, 1 month, as a per cent of the former, or by some equivalent operation with time saved in relearning. No good and much harm may come from this. If it is stated that one boy (*A*) in ten minutes learns 60 words of a 100 word poem and another boy (*B*) learns 20 words of it, and that after a month the two boys remember respectively 30 and 15 words of it, we know what the facts are. But statements of per cents without knowledge of the base may be very misleading. For example, in the above illustration we may be led to think that *A*'s retentiveness was two thirds as great as *B*'s, since he remembered only 50 per cent of his 60 words while *B* remembered 75 per cent of his 20 words, or half as great as *B*'s, since he forgot half of his while *B* forgot only a quarter of his. Memory losses starting from a different base cannot in fact be made commensurate without very elaborate researches to provide a scale of units. In Appendix XV we compare the old and the young individuals measured by Henderson as to the loss from Test I to Test III, pairing with each old individual a young individual who had approximately the same score in Test I. The results show that the differences of any sort between young people of fifteen to twenty and adults of twenty-one to forty in memory are probably very slight. Children of 12 and 13 lost less than the adolescents or adults; children of 10 and 11 lost much less.

We have compared adults of about 22 years with adults of about 42, of equal intelligence, in the memory loss from

77 days, in the case of wrong-hand writing and knowledge of Esperanto.

Seventy-seven days after the test at the end of the practice in writing with the wrong hand, twelve of the group aged 20 to 24 and ten of the group aged 35 or over were tested in the same manner as before. Only one had done any wrong-hand writing in the meantime, and that for only a few minutes shortly after the weeks of practice. All were instructed to try to write as well as they had been writing at the end of the practice. The older group showed an average falling off in quality of .24 point (Thorndike scale), and the younger group a falling off of .16 point. In number of letters written per minute, the average loss was 2.7 for the older and 5.5 for the younger. The individual variation is large, the unreliabilities (P.E.) of the four averages being .14, .10, 1.1, and .9. Counting a loss of .1 of a Thorndike-scale point as equivalent to a loss of 2 letters per minute, we have losses of 7.5 and 8.7 respectively for the old and the young. Their gains by the same method of scoring were 43 and 57. The old thus lost a smaller absolute amount than the young, but it was a little larger per cent of what they had gained. Something near this will be true by any reasonable equating of speed and quality.

Seventy-seven days after the test at the end of the twenty hours of study of Esperanto, twelve of the group aged 20 to 24 and ten of the group aged 35 or over were tested with four tests (vocabulary, printed directions, spoken directions, and paragraph reading) similar in form to those used earlier, and closely equal to them in difficulty, but different in the content. Any difference between the old and the young in the falling off in score is thus a difference in general memory of the language, not a difference in the specific memories of particular words or phrases or paragraphs.

The average drop in vocabulary was 10.8 words for the

old and 9.6 words for the young. The average drop in printed and spoken directions and paragraph reading, all combined, was 4.9 for the old and 0.2 for the young. Using the same assignment of relative importance to the four tests as was used in the case of the original learning, we have 7.1 and 2.0 as the comparative losses of the old and the young.[1] The gains from practice were approximately 25 for the old and 31 for the young.

The two experiments disagree; and both need many more cases to increase their reliability. Also experimentation with other memories is needed. The present indications are that memory loss from disuse is a little greater in the later than the earlier adult years.

The Form of the Practice Curve

In general, such inspection of the practice curves of adults 35 and over as we have been able to make shows no differences between their method of gain and that of younger adults or adolescents. For example, if we eliminate differences between age groups in the total amount of gain by expressing each period's gain as a per cent of the total gain, the curves for the Teachers College group in transcribing letters by a code are as shown in Fig. 15. There is no demonstrable difference between older and younger. The same is true for drawing lines with eyes closed. In the case of wrong-hand writing, the average curve for adults *B*, *D*, *F*, *K* and *V* is shown in Fig. 16.[2] This curve is not observably different from motor-skill curves for young people.

[1] The unreliabilities (P. E.) of the 7.1 and 2.0 are 1.3 and 1.4.

[2] Scores are reduced to one variable by adding 0.4 line for each 0.1 of quality above 7.1 (Thorndike scale) and subtracting 0.4 line for each 0.1 of quality below 7.1.

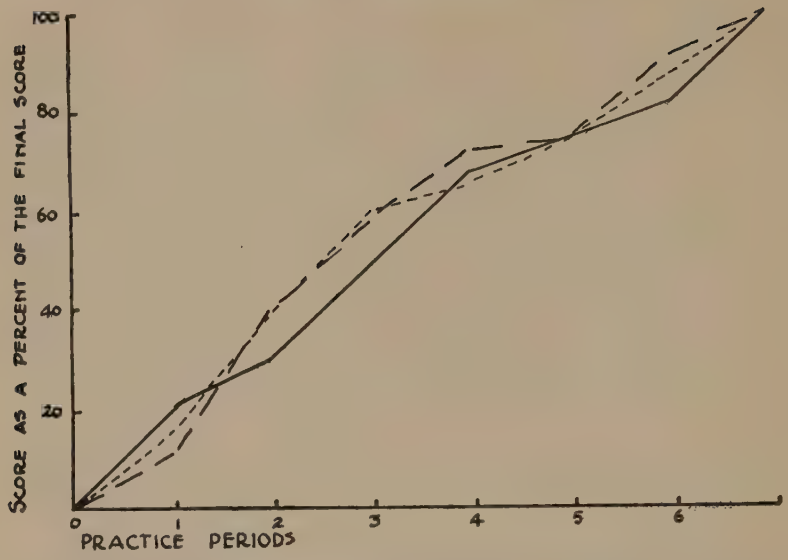


FIG. 15. THE PRACTICE CURVES OF AGES 20–29 (SOLID LINE), 30–34 (LONG DASH LINE), AND 35 OR OVER (SHORT DASH LINE), IN TRANSCRIBING LETTERS BY A CODE.

THINKING AND REASONING

We have studied the work of adolescents and adults who had the same tasks to perform and the same problems to solve, in as much detail as the time at our disposal permitted, in search of differences in the kinds of mistakes made, the kinds of procedures adopted, and other evidences of age differences in the nature of the learning process. Most of the results are negative.

Such few age differences as do appear are usually explainable as the products of special experiences associated with age rather than as products or symptoms of a general inner change in the mind's ways of working. If we had a hundred boys of sixteen and a hundred men of thirty-six study algebra or French or history or civics for a year

and had a record of the thinking of each individual in doing so, I very much doubt whether we could do much better than guess at which was young thinking and which

FIG. 16. THE PRACTICE CURVE OF FIVE ADULTS IN WRITING WITH THE WRONG HAND. EACH POINT REPRESENTS THE AVERAGE OF THREE SUCCESSIVE PRACTICE PERIODS.

was old thinking, except for references to special adult experiences or signs of special interests. In their experiences, interests, and motives adults obviously differ from adolescents, but in the nature of the learning process they are substantially alike, so far as we can see. Our studies of the matter are, however, subject to the limitations of our abilities and facilities; and they should be checked by other observers with other materials. If they are verified, we may conclude that the general laws of learning are substantially the same from fifteen to fifty.

In connection with these general observations on qualitative differences we have made two systematic studies, one on Carelessness and Impulsiveness and one on Dealing with Novelty. The results of these we report briefly.

Carelessness and Impulsiveness

In the *CAVD* test of how hard intellectual tasks a person can do, we may obtain for any individual a record of the number of elements which he has correct out of the 40 elements which constitute each level of difficulty. The number drops from 40 (or nearly 40) out of 40 to 0 or some number representing chance successes, as shown below for five individuals taken at random:

Table 57

The number of task elements correct at levels *I*, *J*, *K*, *L*, etc., of the *CAVD* Test of Intelligence, in the case of five individuals, *H. L.*, *G. B.*, *L. G.*, etc.

	I	*J*	*K*	*L*	*M*	*N*	*O*	*P*	*Q*
H. L.	38	34	36	29	22	16	11	6	5
G. B.	39	34	35	26	28	14	15	8	3
L. G.	39	37	32	36	25	16	13	8	3
W. O.	40	39	37	30	23	12	8	7	..
N. J.	40	38	36	27	24	20	10	5	..

The standard measure for an individual is the level or degree of difficulty at which he would have twenty out of forty right. The way the standard score is obtained does not concern us now; anybody who desires may find a description of it in *The Measurement of Intelligence* by E. L. Thorndike and others on pages 369 to 372.

If now we compare young with old persons who have approximately the same standard measure, say 370 to 379, in respect of how well they do with tasks of Level *I*, which are of difficulty 342, or much easier than 370 to 379, we have a significant comparison. In particular, carelessness would lower the score at 342 by making a person do wrongly elements which he could have done correctly.

In the same way we may compare young with old persons whose standard measures are 380 to 389, in respect of how well they do with the tasks of Level *J*, which are of difficulty 361.

We made these comparisons for nine age groups (14 to 15, 16 to 17, 18 to 19, 20 to 21, 22 to 23, 24, 25 to 29, 30 to 34, 35 and over) for six levels (370–379, 380–389, 390–399, 400–409, 410–419, and 420–429), using the records at Levels *I*, *J*, *K*, *L*, *M*, and *N* respectively. After examining the results, we combined the sexes, since we found no demonstrable difference between the two. We combined ages 14 to 21, since we found no evidence of consistent change with age within these limits. We combined ages 22, 23 and 24, to make a second group, and 25 to 34 to make a third group. We kept 35 or over as a fourth. The results by this grouping are shown in Tables 58 and 59, pages 170 and 171. The older persons show no signs of being more careful. On the contrary they do less well with easy tasks than the younger persons of the same standard score. On the average, if we allow equal weight to the comparisons at each level, the number of easy tasks correct drop .71 from the 14 to 21 group to the 22 to 24 group, .49 from the 22 to 24 group to the 25 to 34

TABLE 58

The distribution of groups of various ages and *CAVD* scores, according to the number of elements correct out of forty at an easy level of the *CAVD* examination (*I* for scores of 370–379, *J* for score of 380–389, etc.).

Number Correct	AGE 14–21						AGE 22–24						AGE 25–34						AGE 35 AND OVER					
	I	*J*	*K*	*L*	*M*	*N*	*I*	*J*	*K*	*L*	*M*	*N*	*I*	*J*	*K*	*L*	*M*	*N*	*I*	*J*	*K*	*L*	*M*	*N*
	370 to 379	380 to 389	390 to 399	400 to 409	410 to 419	420 to 429	370 to 379 One at 15	380 to 389	390 to 399	400 to 409	410 to 419	420 to 429	370 to 379	380 to 389	390 to 399	400 to 409	410 to 419	420 to 429	370 to 379	380 to 389	390 to 399	400 to 409	410 to 419	420 to 429
20																								
21																								
22			1											1	1									
23	2						1	1																
24		2	2																		1			
25	1	2	2											1	1									
26	1	1	5					1					1		2								1	
27	2	8	6	1		1			1					1					1				1	1
28	7	4	7	2	2	1	1	2	2		3	1					1							
29	1	6	9	3	4		1	1	1		1	1			2	1	1							
30	7	13	7	4	8		1	1	3			2	2	1	1		3						3	2
31	4	26	11	5	7	3		2	2		6	1	3		1		3		1					3
32	10	19	6	11	11				2		5	4		3		1	9						3	5
33	13	27	9	22	11	1			3	2	3			1	1	3	4				1		8	5
34	18	33	8	13	16	5			2	1	5	5		1		1	10						2	9
35	16	19	3	12	9	3	2	2		1	5	8					9						2	5
36	26	20	2	5	9	4			1	1	5	3	1	2			12						3	6
37	32	14	4	2	7	4		1			6		2	2			9						10	5
38	11	5		2	11	1		1			1	1		1			8						7	2
39	13	2	1	1	4						2		1				6						4	
40	5				1		1				1													
N.	169	201	83	83	100	23	7	12	17	5	43	26	11	14	9	6	75		2		2		44	43
Av. . .	34.77	32.98	30.66	33.18	34.00	34.17	31.43	31.08	31.24	34.20	33.98	33.54	31.18	32.21	27.89	32.30	34.93		29.00		28.5		35.02	34.02

group, and .67 from the 25 to 34 group to the 35 or over group. These differences are small in comparison with the variation between individuals, and are in need of confirmation by further experiments. But they may at least warn us against thinking that added years produce, generally and uniformly, a greater care in intellectual work. Doubtless adults learn to be more careful in the special occupations which they pursue, so far as it is profitable

TABLE 59

The differences between age groups in the number of elements correct out of forty at an easy level of the *CAVD* examination; computed from the averages of table 58.

	AGE 14–21 – AGE 22–24	AGE 22–24 – AGE 25–34	AGE 25–34 – AGE 35 OR OVER	AGE 14–21 – AGE 25–34	AGE 22–24 – AGE 35 OR OVER	AGE 14–21 – AGE 35 OR OVER
370–379 . .	3.34	.25	2.18	3.59	2.43	5.77
380–389 . .	1.90	– 1.13		.77		
390–399 . .	– .58	3.35	– .61	2.77	2.74	2.16
400–409 . .	– 1.02	1.90		.88		
410–419 . .	.02	– .95	– .09	– .93	– 1.04	– 1.02
420–429 . .	.63	– .48	1.20	.15	.72	1.35
Average .	.71	.49	.67	1.20	1.21	2.07

for them to do so, but the boys and girls from 14 to 20 who are their equals at hard *CAVD* tasks, are their superiors in the number of right answers to easier tasks of the same sort.

We have also compared old with young of equal *CAVD* intelligence scores in respect of the proportion which omitted elements are of omitted plus wrong. If age is accompanied by an increase in caution or a decrease in impulsiveness in intellectual operations the old would be expected to write no answer rather than a wrong answer oftener than the young.

The facts for sentence completions, arithmetical problems, and vocabulary are shown in detail in Appendix

XVI. We first compare the sexes to discover whether there is any sex-difference which might prevent us from combining the *M* and *F* records so as to get larger numbers and hence more reliable determinations. The difference is zero or very near it. Omissions ÷ (wrongs + omissions) is higher for the males in 43% of the comparisons, equal in 10%, and higher for the females in 47%. So we combine the *M* and *F* records in what follows.

We next compare the ages up through 24 to see if there are any large, sudden, or peculiar adolescent changes with age which would make it undesirable to increase reliabilities by combining (*a*) 14 and 15 with 16 and 17, and (*b*) 18 and 19 with 20 and 21. There are not; and we so combine them. We also combine 22 and 23 with 24. A summary of the changes with age appears in Table 60. There are many irregularities, but the general influence of age is clearly toward a substantial increase in the per cent which the number of omissions is of the number of wrongs.

The exact amount of this increase and its exact course with age cannot be measured satisfactorily with the data at hand, since our intelligence groups, 360 to 369 and 380 to 389, had no individuals over 34, and since the populations in some other groups were small. The procedures which we have followed are described in Appendix XVI. The increase is found in all three sorts of tasks (completions, arithmetical problems and vocabulary). Our best estimates are for a rise from age 16 to age 32½ from per cents of about 16, 45, and 16 (for *C*, *A* and *V* respectively) to per cents of 25, 51, and 35. The rise seems very much slower from 32½ to 45, the average for the three sorts of work being only about 1 per cent.

In the experiment in transcribing *a*, *b*, *c*, *d*, etc., to 1, 2, 3, 4, etc., with adult prisoners, we have computed what may be termed a symptom of erraticalness in the form of the sum of the losses from any one period of practice to the next succeeding period. The averages for ages 17 to

TABLE 60

Changes with age in the per cent which the number of omissions is of the number of wrong responses and omissions.

	BY LEVEL I			BY LEVEL II		
	Status at 14–17	Change, 14–17 to 30–34	Change, 14–17 to 40 or >	Status at 14–17	Change, 14–17 to 30–34	Change, 14–17 to 40 or >
Completions:						
360–369	22.4	16.1		20.0	22.1	
370–379	14.8	12.5	10.2	22.1	− 22.1	77.9
380	17.1	22.9		14.2	22.2	
390	14.7	− 4.7	− 14.7	10.0	− 10.0	20.0
400	8.7	2.3	− .2	15.9	7.8	9.4
410	3.1	9.2	17.2	18.5	6.9	18.9
420	0	13.0	17.0	10.5	12.5	21.3
Median		12.5	10.2		7.8	20.0
" (weighted)		9.2	10.2		7.4	18.9
Arithmetic:						
360–369	31.1	11.8		42.5	− 10.9	
370–379	25.6	41.1	14.4	48.2	− 48.2	51.8
380	33.1	39.6		53.0	32.2	
390	52.3	0.9	24.6	64.3	− 64.3	19.0
400	30.6	− 8.1	− 12.7	49.8	− 4.3	− 16.1
410	24.6	15.8	9.6	52.4	8.2	9.6
420	0	57.1	72.9	61.5	− 5.4	− 9.9
Median		15.8	14.4		− 5.4	9.6
" (weighted)		15.8	9.6		− 4.3	9.6
Vocabulary:						
360–369	14.8	47.7		21.5	33.0	
370–379	15.5	− 15.5	34.5	15.7	− 15.7	− 15.7
380	12.1	27.9		22.3	11.0	
390	11.8	− 11.8	− 11.8	33.8	− 23.8	3.7
400	11.9	15.2	13.1	19.8	7.9	17.2
410	15.6	21.5	16.3	23.5	19.6	8.4
420	0	24.3	26.2	0	36.4	22.6
Median		21.5	16.3		11.0	8.4
" (weighted)		21.5	16.3		19.6	8.4

24, 25 to 34, and 35 or over are 32.6, 31.1, and 31.7. The differences are very small; the oldest group are almost exactly equal to the average of the two younger groups; and the probable errors of the differences are about 3.0. So they show little or no difference in violence of fluctuation between the older and the younger adults.

The net result from these three lines of evidence seems to be that the older manifest little more caution and care in intellectual operations than the young adults or adolescents.

Dealing with Novelty

Adults are proverbially less ready to adopt new ways, or even to try new ways, than adolescents. This may be due to the fact that they already have habitual ways which are satisfactory to them. But conceivably there may be a fundamental general unreadiness, or even inability, to deal with new situations. If the latter were the case, it should be revealed in the following experiment: Let young and old who make approximately equal scores in a composite of 10 sentence completions, 10 arithmetical problems, 10 meanings of words, and 10 tasks in paragraph reading, be compared as to their scores in the completions and in the directions or reading tests. The sentence-completion task is one which most of them are meeting for the first time. The directions task is in general of a more familiar type and also depends upon particular ideas and habits that are more familiar. By the hypothesis in question, therefore, the difference, directions score minus completion score at the same level, should grow more and more positive with increasing age. It does. Table 61 presents the average $D - C$ differences for each age group, allowing equal weight to the two sexes. There is further classification according to the *CAVD* score; and those in any one group were compared in exactly the same C and D tasks. The tendency to do

better with *D* than with *C* of the same level rises rather than falls with age, but the rise is small and uncertain.

TABLE 61

The difference, directions score minus sentence completion score, in groups compared in respect of the same *CAVD* level, for five age groups.

CAVD SCORE	14–17	18–24	25–29	30–34	35 or >
360–369 . . .	− 1.0	.7	.4	− .9	
370–379 . . .	.6	.7	.3	2.3	4.0
380–389 . . .	1.0	.9	.7	3.7	
390–399 . . .	.3	− .8	− 1.1	.9	− .6
400–409 . . .	− .1	0	− .3	.4	.1
410–419 . . .	.3	− 1.1	− .4	− .6	− .1
420–429 . . .	− 1.4	− 1.3	− .3	− 1.6	− 1.0
Median . . .	.3	0	− .3	.4	− .1
Average . . .	− .04	− .13	− .1	.6	.5

TABLE 62

The difference, vocabulary score minus sentence completion score, in groups compared in respect of the same *CAVD* level, for five age groups.

	14–17	18–24	25–29	30–34	35 or >
360–369 . . .	− .2	1.8	2.5	2.4	
370–379 . . .	1.0	1.3	2.8	2.5	5.0
380–389 . . .	.1	1.0	1.0	3.5	
390–399 . . .	.6	.4	− 1.1	3.0	1.2
400–409 . . .	.3	.3	.7	.5	.8
410–419 . . .	.7	− .4	− .7	0	.6
420–429 . . .	− 1.4	.6	.1	.4	1.4
Median . . .	.3	.6	.7	2.4	1.2
Average . . .	.16	.71	.93	1.76	1.29

In the case of the difference of vocabulary score minus completion score, there is a large positive increase with age. Any possible greater unreadiness to attack new

tasks is in this case reinforced by the tendency of the older to have gained in vocabulary from their longer experience. The $V - C$ difference rises from about .2 at 14 to 17 to about 1.6 at 35, but we do not know how much, if any, of the effect is due to novelty. The facts appear in Table 62, page 175.

CHAPTER XIII

Practical Applications

In general, nobody under forty-five should restrain himself from trying to learn anything because of a belief or fear that he is too old to be able to learn it. Nor should he use that fear as an excuse for not learning anything which he ought to learn. If he fails in learning it, inability due directly to age will very rarely, if ever, be the reason. The reason will commonly be one or more of these: He lacks and always has lacked the capacity to learn that particular thing. His desire to learn it is not strong enough to cause him to give proper attention to it. The ways and means which he adopts are inadequate, and would have been so at any age, to teach him that thing. He has habits or ideas or other tendencies which interfere with the new acquisition, and which he is unable or unwilling to alter. In the last case mere age may have some influence. A person's gait, posture, speech, and the like are acquired very early in life. They condition later acquisitions, and they may to some extent impose inescapable limitations.[1]

In general, teachers of adults of age 25 to 45 should expect them to learn at nearly the same rate and in nearly

[1] The commonest alleged case is the acquisition of a perfect pronunciation of a language after childhood. This appears, however, to have been exaggerated. Philologists and phoneticians (and some actors) seem able to learn these linguistic habits at late ages, managing to build them up parallel to, and undisturbed by, the vernacular habits which ordinarily interfere with them. The fact is that these very fine motor adjustments are hard to learn at any age. The child spends a large part of the years from two to seven in learning to pronounce vernacular words of the mother tongue properly.

the same manner as they would have learned the same thing at fifteen to twenty. What that rate and manner will be depends upon the general intelligence and special capacities of the individual. Men and women of the dull half of the population will not at any age learn after the fashion of high-school pupils, who are, almost without exception, from the bright half. Individuals in this country who leave school to go to work at fourteen are in general much duller than those of the same community who leave at later ages. Those of them who return to study later in evening schools or correspondence schools are probably much brighter than those who do not so return, but their exact status is uncertain. Adult immigrants who add to the burdens of life in a strange land the work of studying in night schools are probably much above the average for adult immigrants as a whole from the race in question. The adult workers awarded scholarships for study at Bryn Mawr and similar summer schools are probably all in the top tenth of their group for intellectual ability and aspirations.

If an adult class were to be divided into two sections, one expected to make rapid progress and the other expected to make slow progress, age would be practically worthless as a basis for the division. Amount of schooling, in the sense of grade reached, would be enormously better. School grade reached, plus a measure of the shortness of the time to attain that grade, plus some reasonable intelligence test, would be better still.[1]

The provision of opportunities whereby adults can learn those things which they are able to learn and which it is for the common good that they should learn is a safe philanthropy and a productive investment for the nation.

[1] Grade reached in school would be valuable irrespective of whether any use was to be made in the new study, of what had been learned in school. For the grade reached in school is itself a rough indication of intelligence. Each promotion is a certification to a higher and higher level of intellectual ability.

When, on the other hand, wily advertisements or over-enthusiastic propaganda seduce persons to enroll in courses for which they lack capacity, or interest, or both, there is sure to be waste and disappointment. Age, in itself, is a minor factor in either success or failure. Capacity, interest, energy and time are the essentials.

Those in charge of enterprises for adult education ought to be provided with means for administering a system of admission and classification that will be even more searching and decisive than is customary in schools for the young. The variability of the applicants is likely to be wider than at any point of admission, promotion, or classification of the young. The failure to exclude incapables is more likely to degrade the instruction given to their level, because general standards to guide the instructor are lacking.

Adult education suffers no mystical handicap because of the age of the students. On the other hand, it is not freed by the nature of its clients from any of the general difficulties — of adaptation to individual differences, stimulation of interest, arrangement for economy in learning each element, and organization of the subject of study so that each element of learning shall help all the others as much as possible and interfere with them as little as possible. In particular, the argument that the adult student who takes a course voluntarily will be much more interested in study than the young student who takes it more or less by parental compulsion, so that the stimulation of interest requires far less care and skill in adult classes, is likely to be given too much weight. The adult, too, is often interested not in the day by day studying itself but in something ulterior — in the promotion, or social advantage, or self-esteem which he gains. Adult education has an obvious handicap when, as is usually the case, its students have worked through the day and so must resist the cravings to indulge in some favorite form

of rest or entertainment. In individual cases it may be undertaken at great sacrifice.

On the whole, the facts of adult learning are a strong support to those who have given time and thought and money to adult education.

The facts of adult learning may also encourage industry to face changes in machinery, processes, and the like with the hope of reducing disturbances by education of the workers. The writer, at least, is sure that the hand weavers who were thrown out of work by the invention of the power loom could in most cases have been taught not only to use the power looms, but also to make them and repair them, or to be useful in whatever factory work or trades were short of employees at the time. A steady, industrious, reliable worker has qualities of body and mind and morals which are too important to be wasted because some industrial change has destroyed the value of the special work which he has hitherto performed. Public or private provision for his education for some suitable work seems highly desirable, and likely to cost less and succeed better than has been supposed.

His fear of failure and of being an object of unpleasant attention or ridicule, accentuated by the depressed condition which the loss of his habitual living and life tend to produce, should be allayed or allowed for so far as possible. General awareness and acceptance of the truth about adult ability to learn, and a wider prevalence of adult education will help in this. If his new education is as one of a group in similar circumstances and is provided without the imputation of inferiority to him it will be more acceptable and more successful.

In some cases the change can be foreseen and the education for the new work can be provided by the old employer. Thus a railroad, when it electrifies certain sections, may educate some of its steam engineers to be motormen. This was done by the New York Central lines,

and I understand that their example has been followed successfully by others.

Besides these applications to existing forms of adult education, and to education as a palliative in industrial changes, there are possible applications to our general scheme of education. We may introduce these by considering the question, "What are the advantages of concentrating schooling in childhood and youth as is now so universally done?"

Freeman ('17 p. 149 f.) suggests that learning in early years is advantageous for the purpose of attaining the highest skill, and in cases where the learning consists in imitating another person. He writes:

> To attain the highest skill, one should begin early; but the child learns more slowly than the adult. Two forms of this question should be distinguished. We may ask first whether children can reach a higher degree of attainment than the adult; or whether a person can reach a higher attainment when he begins as a child than when he begins at a later age. . . . It will probably be conceded that in order to reach the highest degree of ability in motor skill, it is usually necessary to begin during childhood, though there are exceptions to this rule.
>
> . . . The child's plasticity is an advantage from the point of view of final attainment, and a disadvantage from the point of view of rapid progress. . . . It may very well be that the adult can attain more rapid improvement because he has more older habits which can be applied in a new problem, but that he cannot finally attain such a high rank, because of the fact that the older habits are not exactly like the ones which have to be formed in the new task, and that therefore they interfere with the formation of the newer habits. This conclusion would seem to be supported by the fact that adults rarely learn to pronounce foreign languages without an accent.
>
> . . . The child's plasticity favors imitation as a method of learning. When the adult sees another person perform a new act he has a tendency to translate it in terms of acts which he himself can perform. He is limited, so to speak, by the vocabulary of action which he already possesses. He may not realize that he is failing to copy the teacher accurately, and this places a limitation upon progress. The child begins without such

definite habits of movements and therefore he is in a position to copy more faithfully the model which is set before him. Since the nervous impulse does not have such a pronounced tendency to flow into particular channels, there is greater freedom for the child to develop the channels of discharge which will produce a movement most like the one which he is attempting to imitate.

These assertions are by no means certain. But even if they were, they would be rather feeble arguments for concentrating education in childhood; and Freeman probably would not intend them to be so used. The attainment of the highest motor skill requires not only an early start, but an enormous amount of practice, and is rarely an aim of education, perhaps for one person in a thousand. Learning by a diffuse childish activity out of which an imitation of a model somehow emerges is not an especially admirable kind of learning, nor on the whole so good as the deliberate planful imitation of an actor or gymnast or phonetician.

Edwards defends the doctrine that "acquisitions are to be made as early as possible" partly on the ground that pupils will thus have a better foundation and partly on the ground of Yost's law. ('20, p. 71 f.) If, however, a thousand hours of study is required to provide a good foundation at say twenty, it is better to spend it from fifteen to twenty than from ten to fifteen, and much better than to spend it from five to ten. As to Yost's law, a few months are adequate to obtain its advantages and no time at all is needed if we put what we learn to use immediately. In that case the practice coming from such use will fix the learning.

The answer oftenest given by those concerned with the theory or the practice of education would be that, "The mind is then much more plastic, easier to mold into desirable ways, that is, much more educable." We have seen that in so far as plasticity means ability to learn, the

"much" is certainly inappropriate. If there were nothing in favor of early schooling save the greater mental plasticity of youth, in the sense of youth's greater ability to learn, we might better replace "Childhood is the time for learning" by "The time for learning anything is the time when you need it." For there are great advantages which accrue when learning satisfies some real need, benefits some cherished purpose, and is made use of at once and so is kept alive and healthy for further use.

Plasticity, however, may mean to those who invoke it something more than ability to learn; and learning in early years may have other recommendations than plasticity.

Let us then consider the general question of the placement of schooling in relation to age. If a given amount of schooling, say ten thousand hours, is to be given, when shall it be given? What are the advantages of concentrating it in the years from six to sixteen, as is now done? What might be gained from delaying some of it to adult years? If it is possible and desirable to increase schooling by another thousand hours, shall this be put as an addition of five hours a day for five days a week for forty weeks at age sixteen? Let us first set in order the main facts in favor of concentration of schooling in early years.

A human mind develops in part by inner growth, getting and improving certain mental powers as one gets his teeth and stature and strength. This process of development by inner forces is, in most respects, completed by twenty or earlier. If outside forces, such as schools, are to accelerate, check, redirect, or otherwise alter it, they must in the main act during the years before twenty.

A human being will learn in early years. If the ideas then absorbed are wrong, they must be eradicated. If the habits then formed are harmful, they must be broken. Unlearning errors is a most wasteful form of learning. If schools act on these early years they have the possibility of forestalling much practice in error.

The appeals of sex, power, display, and other natural appetites are so strong that abstract and idealistic interests need reinforcement to hold their own against them. The interests in play which characterize childhood are not so antagonistic to these abstract and idealistic interests and occupations, and may even be used by schools to build them up.

The child, having been dependent upon the adult for food, shelter, general care, and information, is more obedient, acquiescent, and teachable (in the sense of modifiable toward what adults wish him to be) than he will be later. This may not be an argument for concentrating schooling in early years, if the reader sets a low value on docility and conformity and a high value on self-determination, self-expression, and self-government.

We can learn nearly as well when young as when older, but our value as workers at home or elsewhere is far less. So it is wise to go to school when the money value of our time is low.

Other things being equal, the earlier a thing is learned the longer, and so the greater, the use which can be made of it. If it is an advantage to be able to read, it is better to be able to read from eight to eighty than from twenty-eight to eighty.

The last half dozen paragraphs about growth, habit formation, protection of abstract and idealistic interests, teachableness, the small economic value of child labor, and the longer service of early acquisitions state facts which are demonstrated or demonstrable and must be reckoned with by any scheme for the placement of schooling in relation to age. We may now consider certain facts which are less certain, or, if certain for the present state of the world, need not be so for some conceivable set of people and customs.

The pleasures of learning things together in a social group are, or may be made, very desirable to children.

They are, or may be, acceptable as a form of gregarious play. The pleasures which adults would derive from a similar activity are less. A greater happiness of a greater number is gained by going to school in childhood and staying at home or at work in adult years.

If children are not in school for the twenty-five hours a week they will be at work for hire under the control of employers or at work or play under home control. It is less safe to trust employers with children than with adults. The latter can protect themselves better against misuse. So it is better to be out of the control of an employer when young than for an equal time when adult. It is similarly less safe to trust adults with children than with other adults. The rich may spoil them by overindulgence, and the poor may spoil them by overwork. The state, which has a certain quantum of protection to afford, uses it most wisely in protecting the young by schools.

Schooling in early years is usually democratic and non-sectarian and impartial. Children of all races, economic levels, creeds, and traditions live and learn together. If part of it were spread along through adult years, that part would tend to be organized for specialized groups with more or less invidious distinctions.

The strength of arguments derived from these facts and possibilities varies with the earliness of the time of education. They weaken as we pass from the age of five to fifteen, eighteen, twenty-one, twenty-four.

If we consider the arguments in connection with the three schemes for the distribution of ten thousand hours of schooling shown in Figs. 17 to 20, page 186, we shall have little doubt that they justify the plan of Fig. 17 rather than that of Fig. 18, but we shall be somewhat hesitant to assume that they justify the plan of Fig. 17 rather than that of Fig. 19, or that of Fig. 20.

This hesitancy should increase with closer scrutiny of the arguments for an early placement of schooling from the

Fig. 17

□ = 100 HOURS OF SCHOOLING IN FIGS. 17, 18, 19 AND 20

Fig. 18

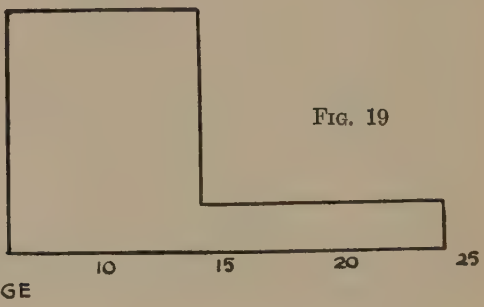


Fig. 19

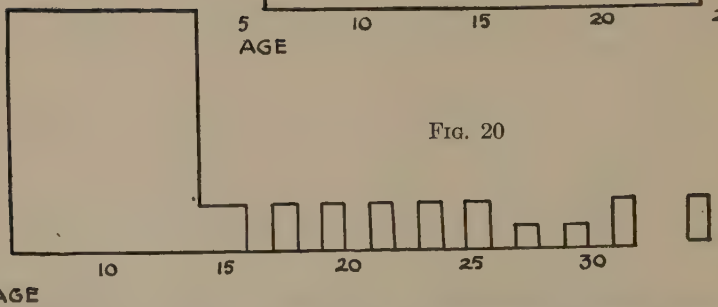


Fig. 20

Figs. 17, 18, 19, and 20. Four Ways of Distributing 10,000 Hours of Schooling. In Fig. 17 it is Concentrated in Ten Years, from 6 to 16. In Fig. 18 it is Spread Evenly over Thirty-three Years. In Fig. 19 Four Fifths of it Are Spent from 6 to 14, and One Fifth is Spent from 14 to 24. In Fig. 20 Four Fifths of it Are Spent from 6 to 14, and One Fifth is Given in Instalments of 100 or 200 Hours per Year, in Various Years from 14 to 35.

need of furthering desirable growth, the danger of forming habits that will have to be broken, and the general protection of childhood.

It is certainly desirable for the world to remove impediments that check desirable growth in body and mind and to provide such environments as will stimulate it. But it is doubtful whether, from fourteen to twenty, schooling as such is better than work as such, as a stimulus and directive agent for the inner growth of the great majority. We know very little about what is good or bad for the process of inner mental development, and almost nothing about the effect upon it of schooling or work of any sort. *A priori* the psychologist would suppose that some assumption of power and responsibility was a very valuable stimulus in these years. Self-support, in whole or in part, seems as desirable then as being loved and cared for is in infancy. Sharing in adult enterprises also seems likely to develop a person in his teens.

We can of course, devise forms of schooling which bid fair to be much better for inner growth than the average forms of labor open to boys and girls in their teens. But we could also devise forms of labor which would be so. It is significant that the changes made in schools to improve them from this point of view often seek to duplicate the "real world" in general in the school. Why should the chief activity of the real world be so rigorously excluded? The history of schooling does not warrant a bigoted optimism concerning schools as benefactors to inner growth. They have indeed been chief sinners. According to the best present theory, the silent, motionless, memorizing elementary school, which was in vogue until about a generation ago, repressed and thwarted and deformed mental growth.

Leaving general and *a priori* considerations and turning to detailed observations of fact, we find the well-known work of Woolley with Cincinnati children. The children

who stayed in school from fourteen to sixteen or eighteen were superior at sixteen and at eighteen to those who worked from fourteen to sixteen or eighteen. They were superior at fourteen, before the difference between school and work acted. They increased their advantage from fourteen on in some respects and lost ground relatively in others. It is difficult, if not impossible, to differentiate the action of schooling after fourteen, *per se*, from the superior nature and home nurture which accompany it. It is also difficult, if not impossible, to differentiate specific school learning from a subtler general stimulation and guidance of inner growth. Woolley herself says: "When we first began the present study, our chief interest was that of attempting to determine the effect of industrial life upon children who left school and entered industry as early as the law permitted. Now that our study is complete, we find that very few of the facts obtained offer any possibility of unequivocal statements on this point." ('26, p. 725)

On the whole it seems that attention and money spent to provide proper food, sleep, freedom from serious illnesses, dental care, appliances to correct for sense defects, ultra violet radiation on the body, good companions, and good books will produce better returns in respect of the inner development of both the body and the mind, than equal amounts spent in any other ways that we now know about.

A delay in the age of schooling, all else remaining the same, will result in the acquisition, up to the time of the completion of schooling, of more of the ideas and habits of the groups (real or ideal) among whom the individual lives (in reality or in thought), and fewer of the ideas and habits of the school. The chief differences will be in formal matters like pronunciation and grammar, where the school systematically corrects common practice, and in factual matters, where the school replaces superstitions

and fantasies of various sorts by facts of science and history. Other things being equal, making these corrections and replacements early rather than late is a real advantage, diminishing practice in error. We may think of schooling as doing three things. The first is speeding up learning which life, apart from school would eventually provide for (such as knowledge of common measures in arithmetic; inches, feet, yards, etc.). The second is the causing of certain learning which life, apart from school, would usually neither help nor hinder (such as knowledge of how to read Latin, or to solve quadratic equations). The third is causing certain learning which is often opposed by life apart from the school (such as that ghosts are not real, or that cultivated people do not say "he don't").

Early schooling tends to be wasteful in the first two lines of effort by teaching things too long before they are needed, and things that never will be needed. But it clearly has advantages in the third. How important these advantages are relative to others depends upon what the content of this third field is in any day and generation.

The argument from the desirability of using childhood for innocent pleasure loses strength after the age of twelve, and loses strength very rapidly after fourteen or fifteen. A very large percentage of children then prefer to work eight hours a day rather than to go to school for five. Schooling does not appeal to them as a vital or engaging occupation. They then want things which money will buy, and the powers which skill in shop or trade or office gives.

The arguments for the general protection of children from misuse by employers or by parents also lose strength as we pass into the teens. Boys and girls of fifteen are more like adults than they are like children of ten in size, strength, intelligence, self-assertion, and desire for mastery. Doubtless, there are individual cases that need protection, but it seems undesirable that these should be given much

weight in deciding a general policy. Moreover, many of these boys and girls of fourteen and fifteen would rather do the work of farm or factory than the work of school. The teachers may be far gentler than the employers, but still be less tolerable to dull pupils who are kept at lessons for which they have little ability and less liking.

If we suppose that an eleventh and twelfth thousand hours are to be made available, these arguments for the desirability of concentrating such additions in early years, as by extending the age of compulsory attendance to seventeen or eighteen, become more questionable still.

Let us now turn to the chief facts in favor of allotting a much larger fraction of schooling to adult years than present or past practice has done. They can be presented very briefly.

First, a better selection of persons to be taught could be made. The abilities and interests of individuals can be better known with each year of their growth and experience.

Second, a better selection of the content of instruction could be made, both for persons in their general capacity of individuals, neighbors, and citizens, and for their special duties and privileges as producers and enjoyers. In the early years, many features of history and the social sciences cannot be properly apprehended because the learners lack direct experience of certain facts of life.

Vocational education of all sorts in early years is likely to be wide of the mark because the individual often does not know just what he wishes to do, or is fit to do, or can, under existing conditions, earn a living by doing.

Third, a better arrangement and sequence of learning can be provided. The Dewey doctrine of "First the need, then the knowledge or technique to satisfy the need," can be applied in as thorough-going a way as is desired. The young man who is working in advertising can study salesmanship or psychology. The young woman about

to be married can study domestic science. The worker who becomes interested in writing can study English composition.

Fourth, a loss of abilities by forgetting or of time by relearning can be prevented. Children now learn about voting in civics in grade 7 or 8, seven years before they can vote. They learn the arithmetic of notes years before they will probably have any occasion to borrow or lend money on a note. Certain facts of history and geography they learn only to have entirely forgotten them when the occasion to use them arrives. Other things being equal, the best time to learn anything is just before you have to use it.

Fifth, the lag of schooling behind science and technology can be lessened. When knowledge is advancing as rapidly as it is now, too much of what we learn from ten to twenty tends to be out of date when we are forty. When civilization was more stable and the arts and sciences progressed slowly, it was in general satisfactory for one generation to use during life what it learned in its teens. A man of sixty doing only that now would be in many respects a nuisance and a danger. He would be, for example, unable to drive the commonest vehicle, or to turn on and off the commonest form of light. He would endanger life by neglecting fundamental sanitary precautions. A large part of the social and religious beliefs of the young people of to-day would be quite incomprehensible to him. A progressive development of the sciences and arts needs continuous education either in school or out.

Sixth, there is a real danger that, in our zeal to give young people the blessings of more abundant schooling, we may be depriving many of them of the satisfaction and instruction which comes from doing something well, measuring up to standard in some respect, accomplishing something in such a way as to earn their own self-respect. Unless the character of schooling is changed in funda-

mental ways, the fate of from a quarter to a third of the boys and girls of fifteen and sixteen and seventeen, if these are all retained in school, will be one of these:

They will be held back in classes and slowly gain mastery of rudiments of little use to them, such as are now taught commonly in grades seven and eight. They then learn to hate learning. Or they will be forced to try to learn things which they simply cannot learn, such as algebra or Latin or economics. They then learn to fail and to expect to fail. Or they will be more humanely switched off into trade schools, where they will lead happier and more useful lives, but perhaps not so happy or useful ones as they would lead if they were engaged outright in productive labor. If they were out of school for one or two of these years, they might be glad to come back to school again five or ten years later to learn something which they really needed for labor or leisure, and might be substantially bettered.

These facts in favor of delayed schooling do not make so impressive a showing or so emotional an appeal as those in favor of early schooling; and most thinkers, after surveying them, will probably still favor concentration in early years even up to about ten thousand hours or to age sixteen. The facts should, however, cure us of considering early learning as a law of nature, or as invariably superior, and of treating learning by adults as something irregular, remedial, casual, and trivial. Furthermore, if a community becomes rich enough to afford eleven thousand or twelve thousand or thirteen thousand hours of schooling for all, it becomes increasingly doubtful whether years should be added on to seventeen, to eighteen, to nineteen, rather than inserted at twenty or twenty-five or thirty.

The placement of schooling cannot be considered properly save in relation to two still broader matters of community arrangements. A scheme of schooling should harmonize with a scheme of productive labor, (including

management), a scheme of recreation, and a scheme of what is called in family budgets the "higher life." A scheme of schooling should also arrange for the distribution of schooling quantitatively and qualitatively, deciding not only how much schooling there shall be and what it shall be, but how it shall be divided amongst the population, who shall be encouraged to go to school for eight years, and who for eighteen, who of the latter shall study medicine, and who shall study law, and the like.

It is beyond the province of this book to present facts about either the adaptation of schooling to a general plan of a community's affairs, or the distribution of schooling among individuals. And, without an extensive survey of them, the significance of the placement of schooling in adult years in connection with them cannot be treated. So we shall limit ourselves to statements which may be misunderstood or disbelieved.

Our theories about schooling, recreation, and the higher life are all somewhat blinded by an unscientific expectation that somebody will grow wheat and bake bread and make shoes and build railroads and manage factories by some such necessary order of nature as makes the sun shine and the rain fall. This blindness is often accompanied by a certain condescension, or even scorn, toward productive labor, which is perhaps a relic of the long centuries of idealization of the leisure class. There is a very real danger that schooling may unfit a community to produce by itself its own necessities, and lead it to depend on industrial mercenaries imported to do all the dirty work.

As a psychologist, considering the intricate hierarchies of customs and traditions and checks and balances by which the instinctive tendencies of man are directed into the operations of modern industry and trade, the writer wonders that the whole apparatus does not crack with the strains to which it is subjected or explode from the passions which it harbors in its vitals. He feels most

devout thanks for his daily bread. So he looks with favor on a mixture of schooling and productive labor, and is unwilling to assume that the latter is a curse to be postponed as long as possible. He sees hope in adult schooling as a means of social health, and is ready to exchange early schooling for it nearly at par.

The present quantitative distribution of schooling in our best communities is almost entirely a matter of public indiscriminate compulsion for certain early years and of entirely private volition thereafter. This seems improvable. Public welfare depends as truly on who goes to school after fifteen as on how many go to school till fifteen. The continued schooling of some individuals is so useful to the nation that it should be assured. Adult schooling is a promising means for gaining flexibility in caring for such individuals. The facts of adult ability to learn should caution us against attaching too much weight to youth in the laws and customs which decide who shall be forced or encouraged to go to school.

APPENDIX I

The Curve of Ability in Relation to Ages for Groups Differing in Amount of Ability

Our special interest in the topic of this Appendix is with ability to learn in the case of able intellects compared with average intellects. What we should like to do would be to make measurements of this ability at intervals of four or five years from seven to seventy in several hundred individuals, sampling the entire range of intellect. Such measurements are, however, beset with very great difficulties to say nothing of their time requirements.

The best that we can do is to attack the problem with such means as can be found. These are the records of the abilities of men engaged in intellectual occupations at various ages, as measured by positions, wages, and intellectual products produced. We have chosen, as the most suitable material of this sort, the life histories of clergymen of the Methodist Episcopal Church. We compare the careers of four groups according to the median salary (exclusive of parsonage provision) at age 40 to 50, in terms of dollars of the value of 1898–1902:

a. those receiving less than $1000
b. those receiving from $1000 to $1499
c. those receiving from $1500 to $1999
d. those receiving $2000 or over

The number of individuals studied was 143, there being 60, 35, 25 and 23 in the four groups, respectively.

We trace the career of each man from age 30 to age 70, who lived to 70 or later, recording the position held and the amount of salary received each year. After making proper allowance for the changing values of the dollar, we compare the four groups as to the curve of salary with age.

These histories are especially suitable for our purpose, because the salaries do on the whole rather closely measure the abilities,

and the variation in ability from the first to the fourth group covers a range from a point not far above the average man to a very high degree of ability.

As we have said elsewhere ('26):

> The work is highly competitive. The Church admits certain men as members of its various sections called "conferences," such as the Maine Conference, the East Maine Conference, etc. Every man so admitted is entitled to a parish or "charge," to which he is appointed annually by the bishop who presides over that conference in that year, until he retires temporarily or permanently. There are arrangements for transfers from one conference to another. There are many parishes or churches or "charges," each supported financially by its local members[1] who are represented by an "official board" which chooses annually the man whom the members wish to have as their pastor, and which tries to secure his consent and that of the bishop. The bishop has full power, but is advised by the district superintendents or "presiding elders," each of whom has general supervision over a part of a conference, say fifty churches. A minister may refuse to accept the post which the bishop offers him in any year, retiring temporarily for that year; but this would injure his repute, and is rarely done. A church may not refuse to accept the minister whom the bishop appoints, and it would not be decent for it to reduce existing salary provisions for that year, though this is sometimes done. But it can make it very clear to him or to the district superintendent that it will make a reduction the following year if he is reappointed. It can also make promises to the candidate whom it does desire.
>
> There are thus n ministers competing for a better appointment than that which they hold; and n parishes[2] competing for ministers whom they regard as superior to the one they have or to others who might be allotted them. The district superintendents compete to get the best possible men for their several districts, in the reassignment which is made annually. Moreover, until 1900 no individual could stay at any one parish or "charge" for more than three successive years, even

[1] With assistance occasionally from general missionary funds, supplied by a central body for the entire country. This, however, was exceedingly rare for the churches considered in this study.

[2] The number of parishes and ministers is of course not absolutely the same at any given date. New churches are established and old churches are given up or combined; and deaths, retirements, permanent and temporary, assignments to non-pastoral work, and the like, are not balanced exactly by the admission of new men. There is commonly a slight excess of parishes over ministers, this excess being taken care of usually by appointing students in theological schools to certain parishes.

if he, the official board of that parish, the district superintendent, and the bishop all desired that he should do so. Since 1900, a minister may legally remain indefinitely, but the turnover has been much the same as before. The average length of stay for 90 parishes taken at random, whose records from 1900 to 1924 were examined, was under three years.

In general, then, salary measures estimated ability rather closely. Any parish (save the few paying the highest salaries) can obtain ministers of greater estimated ability by raising the salary. A minister who improves relatively to his colleagues may expect prompt results in a better appointment. The results of deterioration will be equally prompt. The chief exceptions to this general freedom of competition of parishes for better ministers and ministers for better parishes which concern age are as follows:

(1) The bishops and district superintendents are supposed on the whole to favor the older men, delaying the rate of their decline at the expense of the rate of advance which young men would have if the choices of the parishes were always decisive.

(2) There have been provisions for allowances to ministers upon permanent retirement. These began as informal doles, made by a committee in each conference from funds collected annually and from the profits of the church publishing house. From 1896 to 1908, the rule of giving $10 annually for each year of active service was followed more or less generally. From 1908 on, the expectation has been that one-seventieth of the average salary, exclusive of parsonage, for each year of active service, should be paid annually, a widow receiving half of this amount. It is not clear how often this expectation has been fulfilled. The individual records which we have studied are rather irregular. Payment has depended upon annual collections; the allowance has been considered to some extent a charity; ministers and their widows are still encouraged to waive it. We are consequently unable to judge what the actual results of pension expectations have been in the case of the individuals studied. It seems probable that they have had little effect beyond accentuating the natural tendency to retire rather than accept a post which is far inferior in salary and dignity to the posts held during one's prime.

(3) There are some cases where the individuals concerned have other sources of income and so are free to indulge predilections for special sorts of work, as in missions, or are so devoted to certain aspects of church work as to be careless of the matter of income for themselves and their families. However, the size of the salary is very closely correlated with the general dignity and importance of the post; and we believe that at least 95 per cent of the men in our records were impelled

by personal ambition and family needs to desire as good salaries as they could obtain. So far as the relation of salary to age is concerned, the exceptional cases will cause little distortion of any general relation; for the man who has a private fortune will usual y have it (or the expectation of it) for most of the years from 30 to 70, and the man impelled by special devotion will usually be impelled by it for most of these years.

We may then expect the salary records of ministers who live till 70, to show with approximate truth facts about the relation of earning power to age, the locus and extent of the "prime" of life, and the nature of the change from it toward the weakness of old age.

The records are grouped into four classes:

I. Men whose median corrected 40–50 cash salary is under $1,000
II. " " " " from $1,000 to $1,499
III. " " " " " $1,500 to $1,999
IV. " " " " " $2,000 or over

Table 63, below, and Fig. 21, page 199, show the curve of salary (without parsonage) for the median of each group, corrected to what it would have been if salaries in general had remained at the level of 1898 to 1902. Table 64, page 200, and

TABLE 63

Estimated median salary in relation to age in terms of 1898–1902 values for men whose median salary at age 40–50 in terms of 1898–1902 values is $800, or $1,200, or $1,700, or $2,500

Median Salary, Age 40–50	30–31	32–33	34–35	36–37	38–39	40–41	42–43	44–45	46–47	48–49	50–51
$800	660	704	768	768	796	784	808	808	800	800	800
$1,200	810	930	996	1,032	1,080	1,182	1,248	1,200	1,188	1,194	1,200
$1,700	1,020	1,080	1,199	1,122	1,309	1,488	1,649	1,709	1,700	1,734	1,768
$2,500	1,275	1,425	1,625	1,925	2,125	2,488	2,550	2,525	2,500	2,500	2,475

Median Salary, Age 40–50	52–53	54–55	56–57	58–59	60–61	62–63	64–65	66–67	68–69	70
$800	800	764	752	712	680	649	580	336	—	—
$1,200	1,170	1,272	1,248	1,182	1,026	1,008	996	750	480	—
$1,700	1,768	1,820	1,683	1,564	1,394	1,241	1,122	927	850	782
$2,500	2,438	2,400	2,200	2,200	2,238	1,750	1,600	1,388	875	—

Fig. 22, page 201, show the median salary curves which are obtained when each man's salary for each year from 30 to 70 is expressed as a per cent of his median salary from 40 to 50, all salaries being first corrected as noted above. The procedures

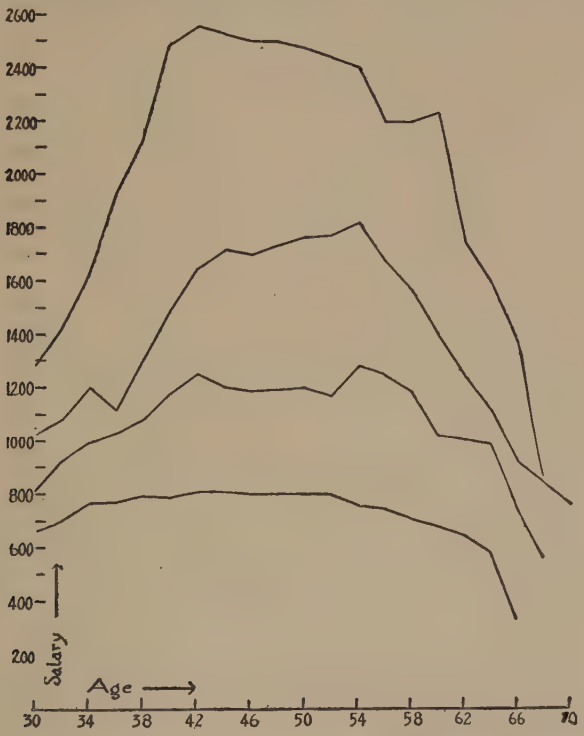


Fig. 21. The Relation of Earning Power to Age. Median Cash Salaries of Four Groups

adopted in obtaining the records, in treating various features of them, and in deriving these tables and curves may be found described elsewhere. (Thorndike and Woodyard, '26, pp. 295–303.)

The dashes entered in the tables represent medians determined only as "0 or very low." They are not plotted in the

graphs. All four groups show a rise from 30 to about 40, a plateau from about 40 to about 56, and a fall thereafter.

TABLE 64

Medians by two-year periods of salaries expressed as per cents of the median salary of the person in question from age 40 to age 50, after transmutation into 1898–1902 values of money. The entries at age 70 are for a single year

GROUP	N	Median corrected salary, age 40–50	30 31	32 33	34 35	36 37	38 39	40 41	42 43	44 45	46 47	48 49	50 51
I	60	Under $1,000 .	82.5	88	96	96	99.5	98	101	101	100	100	100
II	35	$1,000 to $1,499	67.5	77.5	83	86	90	98.5	104	100	99	99.5	100
III	23	$1,500 to $1,999	60	63.5	70.5	66	77	87.5	97	100.5	100	102	104
IV	23	$2,000 and over	51	57	65	77	85	99.5	102	101	100	100	99

GROUP	N	Median corrected salary, age 40–50	52 53	54 55	56 57	58 59	60 61	62 63	64 65	66 67	68 69	70
I	60	Under $1,000 .	100	95.5	94	89	85	81	72.5	42	—	—
II	35	$1,000 to $1,499	97.5	106	104	98.5	85.5	74	73	62.5	40	—
III	23	$1,500 to $1,999	104	106	99	92	82	73	66	54.5	50	46
IV	23	$2,000 and over	97.5	96	88	88	89.5	70	64	55.5	35	—

There are no demonstrable differences in the shape of the percentile curves after 40 that can be related to the differences in ability. The curve for Group IV after 40 is in fact more like that for Group I, than like that for Group III. If we average the results for Groups I and II and those for Groups III and IV we have the following:

AGE	40–41	42	44	46	48	50	52
I + II . .	98.3	102.5	100.5	99.5	99.8	100	98.8
III + IV .	93.5	99.5	100.8	100	101	101.5	100.8

AGE	54	56	58	60	62	64	66
I + II . .	100.8	99	93.8	85.3	77.5	72.8	52.3
III + IV .	101	93.5	90	85.8	71.5	65	55

These facts are shown also in Fig. 23, page 202.

The abler groups do not maintain their plateau longer than the less able. A more extensive collection of histories could make only slight and unimportant changes in this conclusion.

Another line of attack on the same problem is by the use of the careers of men ranging from the most able known in science, letters, art, and affairs down to men just eminent enough to have

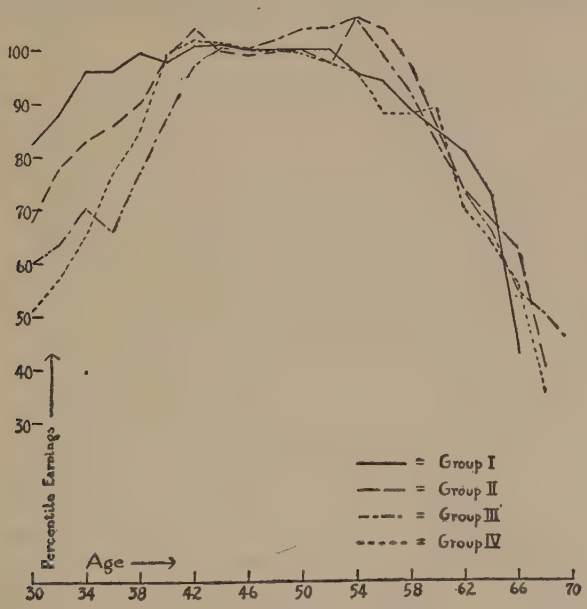


FIG. 22. THE RELATION OF EARNING POWER TO AGE. MEDIAN PERCENTILE EARNINGS OF FOUR GROUPS

their careers reported in biographical dictionaries. We compare the most able with the less able in respect of the date at which they achieved their greatest work. If ability tends to begin its decline later in the able than in the less able, the *magnum opus* dates for the most able should be later than for the less able. (If this is specially true of intellectual ability, compared with energy, courage, the art of winning popularity, and other non-intellectual abilities, the difference should be greater in the case of men of science than in the case of statesmen, reformers, and

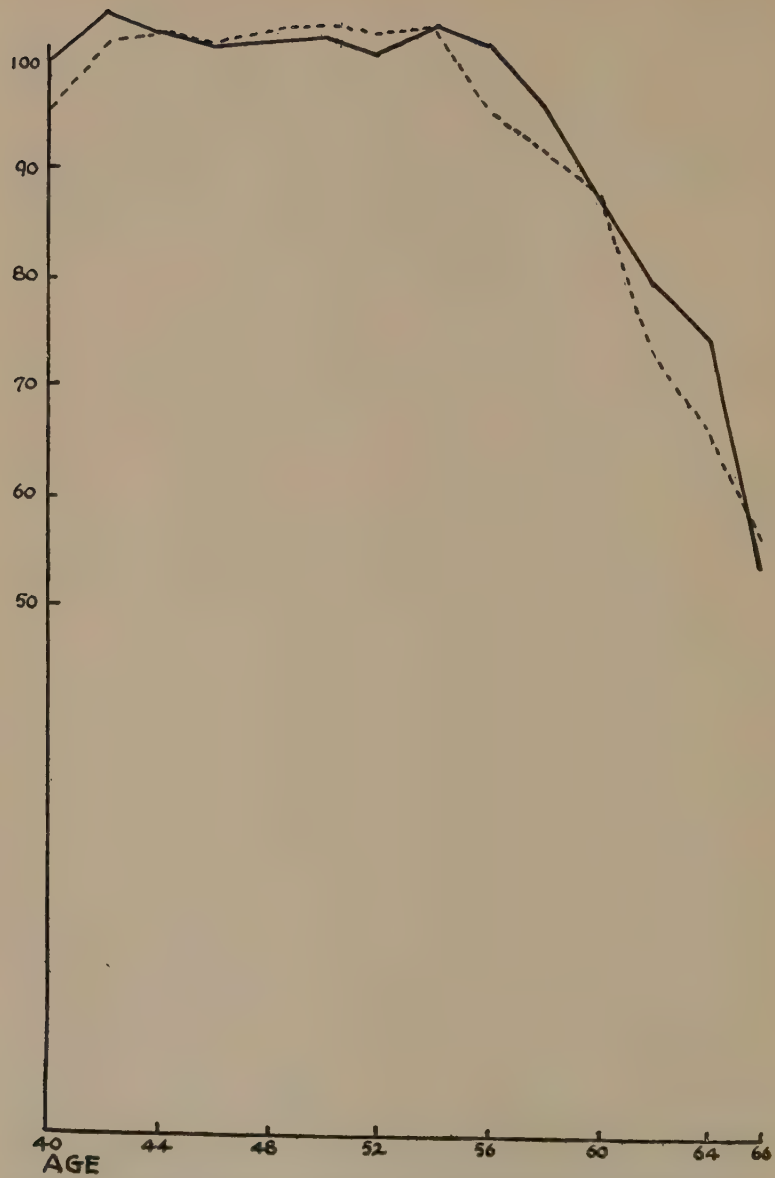


FIG. 23. THE RELATION OF EARNING POWER TO AGE. MEDIAN PERCENTILE EARNINGS OF I AND II COMBINED AND III AND IV COMBINED.

business men.) Finally, the date of the masterpiece for these eminent men should be later than the acme, that is, the middle of the plateau, of the Methodist clergymen (and the date for the very eminent men of science should be much later than the acme for the Methodist clergymen.)

An important, though little known, investigation by Dorland ('08) reports the age of the masterpiece for each of four hundred famous men selected by him. The average age was 50. It is not, however, safe to use this in the comparisons which we wish to make, because proper allowance for the age of death is not made, and because critics might distrust Dorland's selection of his Four Hundred.

We have, therefore, extended his work, using a classification by the age at death in five-year intervals and an impartial plan of selection. We have also limited ourselves to statesmen, reformers, and business men, called hereinafter "men of affairs," and to physicists, naturalists, astronomers, chemists, mathematicians, and inventors, called hereinafter "scientists." The names used were all of men in volumes 1 to 17 of the *Dictionary of National Biography*, for whom a masterpiece could be selected with a fair degree of certainty. Mrs. Ruger, who made the selections, was absolutely impartial so far as concerned age relations. There were in all 331 names.

The investigator began with the first volume of the *Dictionary* and picked out every individual belonging to those groups for whom an *opus magnum* could be selected with a fair degree of certainty. Seventeen volumes were thus covered and 331 records selected. Some of the names were found also in the *Encyclopaedia Britannica* or in the *International Encyclopaedia* or in both. When this was the case these encyclopaedias were used to help in the selection of the *opus magnum*. The average masterpiece age of these 331 records was found to be 47.4, as against 50 for Dorland's 400, and as against 52, the average masterpiece age of the 119 Dorland records belonging to the lists under consideration in the present investigation.

The present investigation also took up the question: Does the age at which the *opus magnum* is performed vary directly with the degree of giftedness? The 331 records were divided into three

groups according to the space given them in the *Dictionary of National Biography*, plus, in the cases of those appearing in the *Encyclopaedia Britannica*, five times the space given them in that.

In Group 3 were put all the records whose space was represented by one page or less. There were 133 of these, 77 scientists and 56 men of affairs. In group 2 were put those whose space was represented by over one page up to and including 3 pages. There were 188 of these, 75 scientists and 43 men of affairs. All the rest were put in group 1. Of these there were 80, 33 scientists and 47 men of affairs. In addition there were placed in group 1 the 119 Dorland records belonging to the present investigation's lists.

In recording the ages at which the *opera magna* were done, an age grouping by fives was used. That is those who died between the ages of 25 and 29 inclusive were considered by themselves, those who died between 30 and 34 inclusive, and so on up to those who died between the ages of 90 and 94.

Consider first the facts for those who lived to be seventy years old or older. The median age of the masterpiece for these was 44 for the men of science, and 53 for the men of affairs. The median masterpiece age for the men rated 1 or 2 was 46 for scientists and 53 for men of affairs. Those rated 3 had median masterpiece ages of 43 and 55 respectively. The median age for all the scientists and men of affairs combined (with equal weight given to men of science and men of affairs) was 49, almost exactly the same as the acme for the Methodist clergymen. The facts in detail appear in Table 65, page 205.

Consider next the men living to 60 but not to 70. The median age for the masterpiece was 45 for the scientists and 51 for the men of affairs. That for the men rated 1 or 2 was 42 for the scientists, 49 for the men of affairs. That for the men rated 3 was 52 for the scientists and 51 for the men of affairs. That for all combined was 48.

These facts support the conclusion from the comparison of able and less able clergymen that the greater ability does not delay its decline till a later date. The men of science have their acme a little earlier and the men of affairs have theirs a little later than the much less able group of Methodist ministers.

TABLE 65

Age at which the man's greatest work was accomplished
S = scientific men A = men of affairs

AGE	MEN LIVING TO 70 OR OVER						AGE	MEN LIVING 60 TO 69 YEARS					
	Frequency of *magnum opus* in							Frequency of *magnum opus* in					
	Class 1		Class 2		Class 3			Class 1		Class 2		Class 3	
	N=17	N=23	N=31	N=25	N=43	N=32		N=9	N=11	N=21	N=10	N=18	N=15
	S	A	S	A	S	A		S	A	S	A	S	A
20							20						
22							22						
24							24		1				
26	1	1	2		1		26						
28			2		1	1	28			2		2	
30					1	1	30		1				
32			2				32			2			
34	1		3		2		34			1		1	
36	1	1		2	8		36	4		1		1	
38	1	1	2	1	2		38	1		2		1	1
40		1	1	1	6	1	40	1	1	1	1		
42	2	2	4		3	3	42			1			1
44			2	1	3	1	44	1	1	2	2	1	2
46		2	2	1		1	46	1	1	3			1
48				1	1		48		3				1
50		1	1	4		5	50					3	2
52	4	4	1	3	2	2	52		1	1	1	3	3
54	1	2	1	2	1	2	54		1		3	1	
56		1	2	3	2	1	56	1	1	1	1	1	
58				1		6	58				1	1	1
60	1				3	2	60			1	1	2	1
62	1	3	2				62			3			
64				1	1	2	64					1	
66				1	3	1	66						2
68		1		1	1	1	68						
70		1			1		70						
72		1		2			72						
74	2		1				74						
76						1	76						
78							78						
80		1	2		1		80						
82	2		1				82						

As a final check we have collected similar facts concerning the acme of achievement of those of the hundred most eminent English writers, from Chaucer to Matthew Arnold, who lived to be seventy or over. Forty-six individuals were used. The masterpiece of each was selected by Miss Wilcox by as objective a treatment of five histories of English literature as was practicable. The median masterpiece age was 47.

In the case of the eminent men of science, affairs, and letters, decision as to which work is the man's masterpiece is often difficult, but any errors made in the decision are harmless for our purposes for two reasons. First, the fact that the decision is difficult means that the one chosen even if wrong represents the man very nearly at his best. Second, the errors are as likely to make the age too old as too young and so will counterbalance one another.

There is also a general tendency for the date to be later than the actual time the work was done. This is also true, in the case of the Methodist clergymen's salaries. It is the achievement of the previous year that determines the salary. Unless the median lag for the eminent men of science, affairs, and letters is much more or less than a year, the comparison is fair. It very likely is more, and cannot be much less, than a year. Consequently our conclusion is substantially safe.

APPENDIX II

The Relation of Ability to Learn to Age: Hollingworth's Data

Hollingworth's original records state the time in seconds to give the correct opposite for each word of a list of fifty in a practice trial on February 4 and in five trials on each day from February 5 to March 2 inclusive. We have thus for each of fifteen individuals a record like that for individual No. 1, shown in Table 66, below.

TABLE 66

Sample of original records in naming opposites

	8 A.M.	10 A.M.	12 M.	3 P.M.	5.30 P.M.
Feb. 4				172.0	
" 5	125.4	120.0	109.8	102.8	98.0
6	71.4	65.2	80.0	80.0	69.8
7	83.0	70.2	74.6	75.6	75.0
8	59.6	57.8	65.8	58.6	63.2
9	54.6	50.2	51.8	58.8	57.4
10	59.6	53.2	61.4	52.6	57.4
11	49.2	59.0	51.8	62.2	55.6
12	55.2	53.6	57.6	68.0	54.6
13	51.0	46.4	51.2	58.4	59.4
14	54.8	57.4	54.8	59.8	52.6
15	50.0	50.0	51.6	61.0	52.0
16	48.2	52.2	49.8	57.2	53.4
17	52.0	48.6	47.4	49.0	50.2
18	53.8	50.8	47.8	53.0	46.8
19	46.8	44.8	52.2	51.4	50.0
20	49.8	46.4	47.0	45.6	59.0
21	44.6	47.8	48.4	49.0	47.4
22	50.2	45.2	45.0	51.6	46.4
23	47.6	43.6	47.0	55.2	47.2
24	40.6	42.2	45.8	44.2	49.0
25	47.2	48.6	43.0	51.2	45.0
26	43.4	44.2	46.0	45.2	49.2
27	43.2	40.0	45.2	45.8	47.8
28	43.4	39.4	45.6	47.0	47.2
Mar. 1	43.4	44.0	40.6	45.0	42.2
" 2	39.6	42.0	42.8	42.6	46.2

TABLE 67

The time required to give the correct opposites of 250 words (in five repetitions of the list of fifty), for each of fifteen individuals on each of twenty-six days. Computed from data of H. L. Hollingworth

	1	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Feb. 5	556.0	607.8	524.0	538.8	384.0	512.8	693.3	860.0	587.6	316.0	424.8	505.0	1765.0	1140.4	341.6
" 6	366.4	420.2	337.8	340.6	293.4	336.4	405.8	579.6	409.0	272.0	373.4	366.2	647.8	453.6	258.0
7	378.4	374.8	305.8	272.0	259.8	250.0	306.2	478.8	372.4	248.6	301.8	290.8	509.6	356.8	243.8
8	305.0	333.9	282.6	[262.5]	234.6	246.4	313.0	432.6	348.2	236.8	304.6	242.8	346.8	342.6	253.2
9	272.8	298.4	284.2	295.6	204.0	230.4	259.8	410.0	376.4	229.8	276.4	260.4	333.6	304.0	215.0
10	284.2	299.3	275.2	251.0	208.6	215.8	313.8	404.6	316.4	223.0	265.8	271.6	286.2	340.4	195.6
11	277.8	293.6	244.8	238.6	183.4	201.6	270.6	406.4	322.8	239.8	269.4	249.2	252.2	317.4	190.4
12	289.0	268.2	237.8	233.0	168.6	196.8	281.0	377.2	312.2	233.8	252.0	236.6	242.6	304.0	183.2
13	266.4	256.6	237.2	218.8	172.0	200.4	256.2	353.8	316.2	217.8	214.6	238.6	216.0	333.0	184.4
14	279.4	252.8	228.4	239.0	159.2	194.2	264.0	316.6	286.8	225.4	235.4	229.8	230.4	271.0	186.4
15	264.6	242.8	217.0	211.4	152.2	176.4	273.0	287.6	289.2	223.4	199.2	228.8	221.2	263.8	171.8
16	260.8	241.2	227.8	207.8	151.0	165.6	263.4	298.6	286.2	218.2	184.4	216.2	209.0	256.8	168.2
17	247.2	223.4	216.8	216.6	146.6	179.8	243.4	258.8	271.0	195.2	184.6	195.0	202.8	237.4	158.0
18	252.2	229.4	205.8	201.8	142.6	162.6	241.4	272.6	260.6	208.8	167.4	227.0	201.6	251.0	152.0
19	245.2	223.0	212.0	203.4	143.0	158.2	242.0	260.2	269.0	210 0	174.0	226.0	200.4	281.4	152.8
20	247.8	210.0	190.0	193.2	130.6	157.4	245.0	268.2	246.2	188.4	176.6	203.4	186.6	261.4	150.8
21	237.2	201.0	186.7	188.8	131.8	155.0	224.0	242.0	266.4	194.4	158.0	209.6	188.2	287.6	146.4
22	238.4	209.6	173.0	175.2	130.0	136.2	219.7	219.2	250.4	183.0	175.0	185.0	184.6	282.0	146.4
23	240.6	199.2	172.2	201.2	127.4	134.6	229.2	232.2	259.8	184.4	148.8	171.4	186.6	279.0	147.6
24	221.8	197.2	168.0	176.6	128.0	144.0	237.8	217.4	242.6	190.8	152.4	161.0	172.4	239.8	144.8
25	235.0	190.2	167.2	170.4	127.8	136.6	225.8	190.2	240.4	178.9	164.6	180.8	170.8	260.6	142.2
26	228.0	183.6	169.8	168.8	131.8	136.8	243.4	182.6	233.8	177.2	156.2	166.4	169.2	253.4	143.8
27	222.0	191.6	167.8	165.8	123.4	136.8	218.4	200.6	252.0	178.0	163.8	168.6	172.0	245.8	140.8
28	222.6	183.2	147.4	165.0	112.6	132.7	227.0	203.8	233.6	166.6	166.4	152.4	148.0	220.4	141.4
Mar. 1	215.2	179.4	153.4	158.8	117.2	123.6	233.8	189.6	231.4	182.8	147.8	150.6	169.0	239.0	134.0
" 2	213.2	180.6	147.8	160.8	121.2	132.6	236.6	183.4	224.8	ill	146.0	148.2	157.4	303.4	137.4

The total time for each day was computed for each subject, giving us a series of twenty-six times for each individual, as shown in Table 67, page 208.

Naming Opposites

The reciprocal of each of the 390 times was computed, giving measures of the number of correct opposites given per unit of time (400 seconds). These facts appear in Table 68, page 210. Two degrees of ability were then chosen to represent the lowest ability which was common to all the individuals (or nearly all) and the highest ability which was common to all the individuals (or nearly all). Those chosen were 250 opposites per unit of time, and 450 opposites per unit of time. All but three of the fifteen individuals began at or below 250 and all but three of them reached 450 or higher. The amount of time required by each person to pass from a rate of 250 to a rate of 450 was computed (or estimated by extrapolation) for all the individuals except No. 8 and No. 15.[1] As a result we have the facts of Table 69, page 211.

The point at which a rate of 450 per 400 seconds was reached was determined by the following procedure: The individual was required to name at a rate equal to or greater than this for three successive trials. To the time spent in the operation up to the end of the preceding trial was added a fractional part of the time of the first of the three successive trials. The fraction was equal to the following proportion: (450 minus the number of opposites named in 400 seconds in the preceding trial) ÷ (the increase in number named per 400 seconds from the preceding trial to the first of the three successive trials). The successive differences were not sufficiently regular to warrant a more elaborate interpolation. The extrapolation was done in exactly the same way. The procedure was similar for the determination of the point at which a rate of 250 per 400 seconds was reached, except that in the case of individual number 10 the requirement of three successive trials above 250 was waived.

[1] The number of repetitions of the opposites would be a much easier measure to obtain, and would be very closely correlated with, and would signify very much the same as, the amount of time; but time is on the whole preferable.

TABLE 68

The number of correct opposites given per unit of time by each of fifteen individuals. Computed from data of H. L. Hollingworth

	1	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Feb. 5	180	165	191	186	260	195	144	116	170	316	235	198	57	88	293
" 6	273	238	296	294	341	297	246	173	244	368	268	273	154	220	388
7	265	260	327	368	385	400	327	209	269	402	331	344	196	280	410
8	328	299	354	381	426	406	319	231	227	422	328	412	288	292	395
9	367	335	352	338	490	434	385	244	266	435	362	384	300	329	465
10	352	334	363	398	479	463	319	247	316	448	376	368	349	294	511
11	360	341	408	419	545	496	370	246	310	417	371	401	397	315	525
12	346	373	421	429	593	508	356	265	320	428	397	423	412	329	546
13	375	390	422	457	581	499	390	283	316	459	466	419	463	300	542
14	358	396	438	418	628	515	379	316	349	444	425	435	434	369	536
15	378	412	461	473	657	567	366	348	346	448	502	437	452	379	582
16	383	415	439	481	662	604	380	335	349	458	542	463	478	389	595
17	405	448	461	462	682	556	411	386	369	512	542	513	491	421	633
18	397	436	486	496	701	615	414	367	384	479	597	441	496	398	658
19	408	448	472	492	699	632	413	384	372	476	575	442	499	355	654
20	404	476	526	518	757	635	408	373	406	531	566	492	536	383	663
21	422	498	536	530	759	645	446	413	375	514	633	477	531	348	683
22	419	477	578	571	769	734	455	456	399	546	571	541	542	355	683
23	416	502	581	497	785	743	436	431	385	542	672	583	536	358	678
24	451	507	595	566	781	694	421	460	412	524	656	621	580	417	691
25	426	526	598	587	782	732	443	526	416	559	608	553	585	384	703
26	439	545	589	592	759	731	411	548	428	564	640	601	591	395	695
27	450	522	596	603	810	731	458	499	397	562	611	593	581	407	710
28	449	546	678	608	888	754	441	491	428	600	601	656	676	454	707
Mar. 1	465	557	652	630	853	809	428	527	432	547	677	664	592	418	740
" 2	469	554	677	622	825	754	423	545	445	ill	685	675	635	330	728

TABLE 69

Naming opposites: Age, estimated time required to improve from a rate of 250 to a rate of 450 (in seconds)* and initial ability

INDIVIDUAL	AGE	PRACTICE TIME TO ATTAIN A RATE OF 250	PRACTICE TIME TO ATTAIN A RATE OF 450	TIME TO IMPROVE FROM 250 TO 450	RANKS IN		
					Youth	Rate of gain	Initial ability
1	39	792.4	6416.2	5623.8	15	12	9
3	39	1204.4	4580.4	3376.0	14	9	11
4	19	703.8	3511.0	2807.2	2	7	7
5	33	840.6	3012.9	2172.3	12	5	8
6	33	347.8	1248.3	900.5	11	1	3
7	19	694.2	1695.1	1000.9	1	2	6
8	24	1114.2	?	?	7	14	12
9	21	3643.8	7556.9	3913.1	3	11	13
10	28	1086.0	7830.4	6744.4	10	14	10
11	27	185.6	2839.4	2653.8	9	8	1
12	24	594.5	2982.9	2388.4	6	6	4
13	22	620.1	4016.5	3396.4	4	9	5
14	27	3126.0	5026.8	1900.8	8	4	15
15	34	1772.4	?	?	13	14	14
16	24	205.8	1265.5	1059.7	5	3	2

* The numbers are entered to a tenth of a second, to facilitate checking. The variability of the separate trials is such that the last two figures are not significant.

An inspection of the records of individuals 8, 10, and 15 in Tables 67 and 68 shows that their general improvement from a rate of about 250 up was about the same. The rank of 13–14–15, or 14, is therefore given to each of them.

The initial ability in naming opposites is measured by the rate for February 5, and the fifteen individuals are assigned ranks for initial ability as shown in the last column of Table 69.

The median ages, times required to improve from 250 to 450, and initial rates are as follows, for the five youngest, five of medium age, and five oldest:

Youngest 5	21	2807.2	195
Middle 5	27	2653.8	170
Oldest 5	34	3376.0	180

The oldest improve somewhat more slowly but they are somewhat less capable at the start; and Table 69 shows that youth, rate of gain, and ability at the start all go together. The

correlation between youth and rate of gain is .32; that between youth and initial ability is .25; that between rate of gain and initial ability is .57.

We may learn what would probably happen if we had young and old, all of identical initial ability, by obtaining the partial correlation $r_{yg \cdot i}$ (of youth with rate of gain, after equalizing in respect of initial ability). This is .07. In a group, all of equal initial ability, youth would then have (as far as this experiment may be trusted) a very, very slight beneficial effect.

We have used the Hollingworth records in naming opposites in another way, measuring the time required to progress from a rate of 160 to a rate of 250. In doing this the five records for a day often have to be treated separately and the first or practice record of February 4 has to be used in some cases. The measures are thus less reliable than those for the change from 250 to 450. We use them, partly, because they give a second independent experiment, and partly because the progress in these early stages is more an intellectual and less a motor improvement than the progress in the later stages.

The resulting ranks for individuals 1, 3, 4, 5, etc., in order, in respect of rate of gain from 160 to 250, are: 8, 12, 6, 9, 3, 4, 14, 15, 11, 1, 10, 5, 13, 7, 2.

The correlation of youth with the rate of gain from 160 to 250 is .12, but the rate of gain correlates with initial ability .82. The estimated correlation of youth with rate of gain from 160 to 250 in a group of identical initial ability is $-.15$.

The initial ability is, however, the sum of all five trials of February 5, and so is partly constituted by the gain from 160 to 250. Some of the rapid gainers will be making the gain from 160 to 250 in part during these five trials. So the partial correlation with true initial ability probably is not so far below zero as $-.15$.

Calculation

The procedure in measuring gains was the same as with the records for the opposites, save that number of repetitions was used instead of time,[1] and that an individual was treated as

[1] This is not because we consider it preferable. On the contrary, our reason or excuse for using the repetitions is that the two correlate very, very closely in this instance, and the computation of the times is very tedious.

having reached a given rate even if he fell off to a lower rate thereafter. The number of repetitions of the fifty additions of 17 required to progress from a rate of 160 to a rate of 320 was measured for all individuals except No. 1, No. 15, and No. 16. No. 1, who was 159 on the second day, reached only 304 on the 25th day and 301 on the 26th. We estimate that 25.5 days or 127.5 repetitions of the fifty additions would have brought him to 320. No. 15 had a rate of only about 80 for the first day, reached 160 on the eighth day, but never reached a rate above 261. His last three days showed rates of 261, 272, and 208. We use in his case the amount of practice required to bring him from 112 to 272. No. 16 attained a rate of 192 as the average of his first day. We use as his measure the number of repetitions required to bring him to 192 + 160 or 352. This was 54.

As a measure of initial ability in calculation, we use the

TABLE 70

Adding 17 to numbers. Ages, estimated number of repetitions of the series required to improve from a rate of 160 to a rate of 320, and initial ability (Time, on Feb. 5, in units of 10 seconds).

INDIVIDUAL	AGE	REPETITIONS TO IMPROVE FROM 160 TO 320	INITIAL ABILITY	RANKS IN		
				Youth	Rate of gain	Initial ability
1	39	25.5 × 5	64	15	15	4
3	39	14.3 "	73	14	11	7
15	34	22.0 "	122	13	14	15
5	33	6.6 "	69	12	2	5
6	33	4.9 "	92	11	1	13
10	28	13.6 "	88	10	10	11
11	27	9.9 "	86	9	7	10
14	27	15.3 "	90	8	12	12
8	24	8.8 "	62	7	3	2
12	24	8.9 "	82	6	4	9
16	24	10.8 "	52	5	8	1
13	22	12.8 "	93	4	9	14
9	21	9.7 "	70	3	6	6
4	19	18.1 "	77	2	13	8
7	19	9.5 "	63	1	5	3

record of the first day. This had been preceded by a single practice with the fifty addings of 17.

The results of these calculations appear in Table 70. The averages in number of repetitions required to improve from 160 to 320 and in time on February 5, for the three age groups are as follows:

	Repetitions	*Time on Feb. 5*
19 to 24	12.2	71
24 to 28	11.3	82
33 to 39	13.1	84

The younger group gain somewhat more rapidly but this is due partly to the fact that they are of better ability at the start. The correlations are:

For youth with rate of gain	r = .20
For youth with initial ability	r = .21
For rate of gain with initial ability	r = .24

Applying the method of partial correlation to discover what would be the relation between youth and gain in a group of identical initial ability, we obtain $r_{yg \cdot i} = .16$.

Coördination — The Three-hole Test of Continued Accuracy and Speed

The procedure in measuring gains was the same as with the records for adding 17 to numbers, except that the individuals were treated in two groups. Group I included those for whom the number of repetitions required to progress from a speed of 333 to a speed of 250, for 500 touches (that is, from a rate of 1.5 touches per second to a rate of 2.0 per second) could be observed, or inferred with fair accuracy.

One individual (No. 9) had a rate of 1.85 on Feb. 5, the first full day. He reached a rate of 2.36 in a little less than 6 days. If we use his very first record on Feb. 4 as a starting point, he progressed from a rate of 1.61 to one of 2.11 in less than three days. We know that in general it is easier to progress from 1.50 to 2.00 than from 1.86 to 2.36. We score him 4 days, which is perhaps a little unfair to him.

Group II included those who never reached the rate of 2.0 and were measured by the number of repetitions required to

progress from a speed of 400 to a speed of 286, that is from a rate of 1.25 to a rate of 1.75.

The facts appear in Table 71.[1] In Group I the average number of repetitions of the task required is 73, 66, and 34 for

TABLE 71

Coördination: The three-hole test. Age, rapidity of learning initial ability, and approximate limit attained

	Individual	Age	Repetitions to Improve from 1.5 to 2.0	Initial Ability: Time on Feb. 7	Approximate Limit attained. Time	Rank			
						Youth	Rate of Gain	Initial Ability	Approximate Limit
Group I	1	39	126.5	329	256	9	9	4	8
	5	33	50	428	259	8	7	9	9
	6	33	41.5	407	242	7	3.5	8	5
	14	27	90.5	307	233	6	8	2	4
	12	24	41.5	346	247	5	3.5	6	7
	16	24	45	320	219	4	6	3	3
	13	22	42	366	245	3	5	7	6
	9	21	20	270	191	2	1	1	1
	4	19	29.5	337	213	1	2	5	2
			Repetitions to Improve from 1.25 to 1.75						
Group II	3	39	72.5	424	289	6	5	4	6
	15	34	78.5	451	284	5	6	5	5
	10	28	62.5	384	269	4	4	2	3
	11	27	36	415	278	3	2	3	4
	8	24	45	371	268	2	3	1	2
	7	19	35	501	263	1	1	6	1

the old, medium, and young sections. In Group II these averages are 76, 48, and 35. The younger adults thus have a decided advantage in rapidity of learning this ability in so far as these individuals are representative.

[1] The detailed records appear in Table 72.

TABLE 72

The time required for 500 touches for each of fifteen individuals on each of twenty-six days; in tenths of a second. Computed from data of H. L. Hollingworth

	1	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Feb. 5	3292	4238	3374	4280	4066	5008	3714	2696	3836	4146	3462	3660	3069	4514	3200
" 6	3108	3740	2968	3912	3836	4410	3512	2444	3770	3730	3534	3634	2994	4242	3102
7	3034	3648	2564	3786	3402	4002	3344	2294	3648	3854	3490	3526	2920	3930	3020
8	2990	3470	2626	3684	3300	3662	3262	2214	3730	3510	3350	3160	2940	3730	2836
9	3058	3532	2684	3556	3310	3514	3098	2090	3530	3164	3590	3122	2920	3772	2538
10	2890	3304	2684	3472	3266	3684	3360	2210	3602	3190	3592	2900	2792	3406	2568
11	2888	3254	2486	3388	3056	3660	3130	2190	3272	3170	3180	2964	2748	3478	2634
12	2638	3160	2382	2918	2996	3016	2836	2090	3168	3112	2992	2830	2594	3516	2528
13	2856	3118	2482	2830	2894	3102	2946	2032	2941	2770	2764	2964	2640	3430	2484
14	2866	3270	2446	2910	2926	2792	2924	2146	3100	3036	3004	2660	2546	3350	2354
15	2712	3088	2424	2808	2684	2592	2676	1972	2996	3038	2798	2776	2320	3108	2356
16	2784	3050	2416	2722	2514	2680	2892	1992	2806	2888	2564	2482	2480	3160	2250
17	2756	2882	2322	2714	2602	2586	2708	2070	2890	2722	2456	2512	2330	2958	2228
18	2744	2920	2204	2894	2474	2900	2784	2112	2924	2674	2500	2520	2344	2878	2318
19	2858	2954	2316	2662	2608	2816	2896	2138	3006	3086	2818	2658	2532	2944	2322
20	2762	2990	2392	2986	2608	2802	3006	2120	2936	3026	2722	2698	2484	2966	2220
21	2694	3100	2370	2526	2526	2832	2928	2188	2730	3056	2566	2590	2410	3084	2212
22	2832	2930	2480	2570	2584	2804	2782	2084	2834	2892	2666	2368	2590	2870	2398
23	2674	2834	2168	2732	2592	2566	2780	2076	2828	2832	2652	2506	2314	2850	2166
24	2656	2926	2174	2652	2430	2708	2694	1874	2710	3126	2650	2504	2370	2946	2148
25	2596	3082	2116	2590	2358	2760	2632	2166	2596	2988	2610	2448	2378	2788	2218
26	2548	3028	2112	2600	2360	2814	2756	2070	2744	3100	2544	2546	2324	2810	2168
27	2600	2916	2252	2820	2484	2940	2818	1924	2690	3112	2488	2544	2406	2850	2288
28	2580	2918	2094	2694	2614	2932	2846	1934	2794	2914	2522	2550	2446	2946	2278
Mar. 1	2494	2992	2160	2754	2550	2856	2678	1856	2804	2904	2446	2462	2484	2920	2274
" 2	2640	3132	2312	2676	2512	2714	2802	2150	2866		2436	2712	2406	3068	2270

Most of these individuals apparently reached their limit in this task, and we have included in Table 71 a measure of this in the form of the average of their five best records. This is of interest in relation to age, since in senility there is a notable loss of motor control, and since precision rather than rate of learning is so important in many trades.

In the fifteen subjects studied, the correlation of youth with rapidity of learning is .83 (.79 for Group I and .89½ for Group II); the correlation of youth with approximate limit is even closer, being .85 (.80 for Group I and .92 for Group II).

APPENDIX III

Detailed Results in Wrong-hand Writing and in Typewriting

TABLE 73

Scores in wrong-hand writing before and after training.

Individual	Age	Intel. *CAVD*	Letters Written in 10 Minutes in Tests 1, 2, 3, and 4												Quality by Thorndike Scale					
			Initial				Final				Gain				Initial		Final		Gain	
			1	2	3	4	1	2	3	4	1	2	3	4	1 + 4	2 + 3	1 + 4	2 + 3	1 + 4	2 + 3
16	20	411	357	375	505	477	807	842	890	768	450	467	385	291	6.3	6.3	6.9	7.1	.6	.8
17	20	402	338	402	456	410	874	892	1043	796	536	490	587	386	6.3	6.8	7.0	7.6	.7	.8
18	21	436	392	422	525	465	771	842	717	768	379	420	192	303	6.9	7.8	9.2	9.1	2.3	1.3
19	21	413	475	397	465	414	811	865	927	777	336	468	462	363	5.6	6.6	7.5	7.6	1.9	1.0
20	21	419	385	354	485	422	785	792	741	684	400	438	256	262	5.9	6.3	8.1	8.5	2.2	2.2
21	22	410	383	393	494	445	770	824	775	688	387	431	281	243	7.5	8.1	8.4	8.3	.9	.2
22	22	438	242	309	310	332	666	761	748	730	424	452	438	398	8.7	8.1	10.0	9.6	1.3	1.5
23	22	412	263	272	327	297	827	787	839	736	564	515	512	439	6.0	6.8	7.1	7.6	.9	.8
24	22	432	285	309	349	359	656	709	694	614	371	400	345	255	6.9	6.7	8.1	7.4	1.2	.7
25	22	447	278	281	288	281	405	547	593	564	127	266	305	283	7.4	7.7	8.7	8.4	1.3	.7
26	23	408	314	306	386	394	615	700	679	584	301	394	293	190	6.4	7.3	8.2	8.3	1.8	1.0
27	23	397	475	464	496	507	633	685	763	633	158	221	267	126	6.1	6.8	8.7	8.7	2.6	1.9
28	23	402	450	443	540	447	683	790	819	730	233	347	279	283	7.1	6.9	9.2	9.1	2.1	2.2
29	24	406	395	406	532	414	732	787	830	722	337	381	298	308	6.0	6.9	8.3	8.5	2.3	1.6
30	24	435	349	358	363	390	703	826	805	754	354	468	442	364	6.0	7.0	6.5	6.9	.5	−.1
31	24	419	437	419	520	511	931	1008	1032	954	494	589	512	443	7.4	8.1	6.5	7.0	−.9	−1.1
32	32	424	363	352	461	378	726	658	725	556	363	306	264	178	6.4	5.8	8.0	7.5	1.6	1.7

TABLE 73—(*continued*)

Scores in wrong-hand writing before and after training.

INDIVIDUAL	AGE	INTEL. *CA VD*	LETTERS WRITTEN IN 10 MINUTES IN TESTS 1, 2, 3, AND 4												QUALITY BY THORNDIKE SCALE					
			Initial				Final				Gain				Initial		Final		Gain	
			1	2	3	4	1	2	3	4	1	2	3	4	1 + 4	2 + 3	1 + 4	2 + 3	1 + 4	2 + 3
33	35	402	382	329	414	417	541	495	561	520	159	166	147	103	6.3	6.2	8.4	8.3	2.1	2.1
34	36	432	309	323	378	351	552	495	566	535	243	172	188	184	6.6	6.9	8.4	8.5	1.8	1.6
35	37	415	489	380	491	364	530	472	581	469	41	92	90	105	6.5	8.0	8.7	8.4	2.2	.4
36	37	423	281	287	337	327	422	393	430	414	141	106	93	87	7.4	7.4	9.5	9.1	2.1	1.7
37	37	403	369	368	399	386	503	461	462	433	134	93	63	47	5.6	6.3	8.3	8.2	2.7	1.9
38	38	414	278	298	349	346	589	535	605	564	311	237	256	218	8.7	9.2	9.3	9.4	.6	.2
39	39	424	369	331	408	402	635	678	662	624	266	347	254	222	6.0	6.5	7.0	7.3	1.0	.8
40	40	406	475	360	349	323	332	352	476	420	−143	−8	127	97	6.6	7.8	9.7	9.7	3.1	1.9
41	41	434	283	290	395	311	374	397	456	404	91	107	61	93	5.8	7.1	7.6	7.5	1.8	.4
42	42	412	363	411	567	550	691	688	684	605	328	277	117	55	7.7	7.4	9.3	10.0	1.6	2.6
43	42	428	323	291	340	311	576	519	640	564	253	228	300	253	7.4	7.7	8.5	8.1	1.1	.4
44	43	417	254	254	363	313	525	470	551	483	271	216	188	170	5.7	5.9	7.5	7.0	1.8	1.1
45	44	404	382	344	437	358	473	373	500	419	91	29	63	61	6.2	6.2	8.0	7.6	1.8	1.4
46	45	422	323	254	254	264	467	446	502	480	144	192	248	216	6.4	7.3	8.5	8.3	2.1	1.0
47	47	422	424	441	561	497	685	748	764	623	261	307	203	126	7.4	8.0	8.1	8.3	.7	.3
48	57	422	274	345	402	392	557	664	629	520	283	319	227	128	6.6	7.3	5.9	6.2	−.7	−1.1

TABLE 74 a

Summary of the results of tests before and after 30 hours of practice in typewriting.

INDIVIDUAL AND AGE		RATE: IN LETTERS PER MINUTE				NUMBER OF ERRORS				TOTAL LETTERS IN 40 MINUTES	TOTAL ERRORS IN 40 MINUTES
		Mem.	Copy	Mem.	Copy	Mem.	Copy	Mem.	Copy		
		1	1	2	2	1	1	2	2		
Bre. 35:11	Early	32.8	42.1	53.2	52.5	12	16	17	37	1806	72
	Late	120.1	104.1	143.8	102.6	13	19	27	24	4705	83
										2899	11
H. 32:0	Early	63.5	56.8	80.0	74.6	7	11	5	3	2749	26
	Late	93.5	105.7	107.5	103.3	16	6	8	4	4100	34
										1351	8
M. 38:7	Early	28.3	32.1	45.3	34.5	7	13	18	17	1402	55
	Late	80.0	77.5	79.7	87.6	9	18	7	12	3248	46
										1846	−9
Wo.[1] 47:4	Early	44.4	52.3	57.6	65.6	6	2	7	8	2199	23
	Late	105.4	82.7	98.0	93.2	17	17	11	13	3793	58
										1594	35
Y. 23:11	Early	16.8	16.3	25.4	29.3	1	4	1	3	878	9
	Late	58.0	44.6	72.6	65.3	6	2	6	5	2405	19
										1527	10

[1] Only 15 hours of practice.

TABLE 74 b

Records of practice in typewriting for *Bre.*, *H.*, *M.*, and *Wo.* Number of lines done in 30 minutes, minus 0.1 line for each error.

A line in the text used for copy equals, on the average, $8\frac{1}{2}$ words or 40 letters.

PERIOD	*Bre.*	*H.*	*M.*	*Wo.*	PERIOD	*Bre.*	*H.*	*M.*
1	21.0	41.5	23.2	34.2	31	62.3	61.0	49.8
2	30	45.6	26.5	37.2	32	63.8	65.9	44.2
3	39.8	49.3	29.2	35.6	33	60.7	58.7	44.7
4	40.2	51.8	31.1	45.0	34	66.6	60.2	46.8
5	43.2	43.6	21.7	47.0	35	58.5	63.5	51.0
6	43.8	48.3	16.5	47.3	36	62.4	71.8	45.8
7	48.9	55.0	15.8	42.0	37	62.0	66.2	41.3
8	45.8	55.3	26.9	51.2	38	63.2	66.5	49.3
9	49.1	56.6	33.7	48.4	39	62.2	68.4	46.1
10	51.1	55.5	34.9	51.1	40	65.3	72.2	47.5
11	50.4	56.4	36.2	41.2	41	63.8	70.4	49.0
12	52.1	56.1	37.1	49.7	42	65.5	61.9	52.8
13	53.7	58.8	36.2	50.2	43	68.5	63.4	46.2
14	53.2	55.9	39.0	47.1	44	68.8	60.3	51.5
15	49.3	57.7	38.7	48.0	45	60.6	67.2	45.8
16	52.8	63.2	37.0	47.9	46	61.2	72.9	49.1
17	51.3	60.0	38.6	47.2	47	69.5	69.4	50.9
18	47.1	51.7	31.2	53.9	48	74.5	73.3	46.3
19	33.4ill	65.1	37.7	46.9	49	55.1	68.3	53.7
20	55.8	54.0	41.9	45.0	50	64.2	69.7	50.4
21	59.8	53.6	32.6	42.5	51	69.1	72.7	48.9
22	59.1	50.9	45.2	41.8	52	68.8	69.2	52.1
23	55.6	54.3	34.0	42.6	53	71.2	74.4	51.1
24	56.7	57.2	43.7	46.9	54	67.0	73.7	53.1
25	60.1	56.5	44.4	45.0	55	69.2	71.4	50.9
26	55.8	56.3	41.2	47.0	56	67.7	63.0	50.9
27	66.3	56.5	48.3	37.9	57	68.4	67.8	54.0
28	59.4	62.4	43.7	48.8	58	69.7	74.4	54.5
29	57.2	58.5	49.2	54.1	59	65.5	72.3	48.6
30	67.3	64.7	41.5	54.1	60	72.2	66.2	52.4

APPENDIX IV

Learning a Logical System

The amount of learning of Esperanto was measured in all cases by the difference between the score attained in an examination given before the learning and the score attained in the same examination given after the learning. This examination consisted of four separate tests. These were:

1. A vocabulary test of 100 words, the Thorndike Test of Word Knowledge, Form A, modified as shown below by putting Esperanto words in place of the test words. The score was the number of correct responses.

Directions

Look at the first word in line 1. Find the other word in the line which means the same or most nearly the same. Draw a line under it. Do the same in lines 2, 3, 4, etc. Lines *A*, *B*, *C*, and *D* show the way to do it. Do all the lines that you can.

A. beast afraid ... words ... large ... animal ... bird
B. baby cradle ... mother ... little child ... youth ... girl
C. raise lift up ... drag ... sun ... bread ... deluge
D. blind man ... cannot see ... game ... unhappy ... eyes

Begin

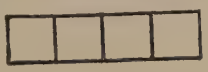
1. tima full of fear ... possible ... necessary ... raid ... ill
2. infaneto manner ... trembling ... little child ... notice ... soft
3. apartigi mount ... pound ... hold ... cut into parts ... add together
4. bezoni revenge ... report ... need ... reward ... return
5. ago play ... deed ... mention ... opinion ... crime
6. atendi pace ... slow ... wait for ... tired ... quit
7. baki cook ... occur ... bacon ... proceed ... peep
8. benko tool ... pull ashore ... opinion ... seat ... pond
9. burĝoni young ... begin to bloom ... sole ... sore ... wither
10. gaja noisy ... silent ... gay ... careful ... splendid

11. rango	odor . . . degree . . . lean . . . lovely . . . main
12. decidi	decide . . . terminal . . . represent . . . retire . . . undermine
13. alpreni	linger . . . orphan . . . pause . . . take over . . . able
14. jara	celebration . . . once a year . . . honorable . . . usual . . . interior
15. flanke	siding . . . onward . . . sidewise . . . hither . . . to one side
16. kredo	feeling . . . hedge . . . faith . . . partner . . . abandon
17. riglilo	iron pin . . . nut . . . passenger . . . pack . . . wrench
18. regno	pause . . . royal . . . link . . . alms . . . kingdom
19. konfesi	agree . . . mend . . . deny . . . admit . . . mingle
20. konfido	trust . . . power . . . heed . . . misery . . . success

2. A reading or directions test of 27 elements or tasks of which Nos. 1, 20, and 25 are shown below. The score was the number of elements responded to correctly. The responses requiring the use of words were given in English.

Read what it says. Do what it says. Where a word is required as the response, write the English word.

1. Faru literon Z el tiu ĉi: 7

20. Se malbona estas la malo de bona kaj amiko estas la malo de malamiko, skribu la literon c sur la punktita linio. Se ne, skribu n en la dua kvadrato.  _____

25. Kiu de tiuj ĉi partoj de la homa korpo estas ordinare plej longa?
finger hand toe leg head _____

3. A test similar in general structure to Test 2, but with the directions given orally, the responses being written in English. It contained twenty-five elements or tasks. The score was the number of elements responded to correctly.

4. Questions 1 to 19 of the Thorndike-McCall Reading Test, Form 1, in Esperanto, with the paragraphs pertaining to these questions. The first paragraph and questions are shown below. The answers were written in English. The score was the number of correct answers.

You are to read paragraphs and questions about them in Esperanto. Write the answers in English. The answers to the questions should be

in accordance with the facts stated in the paragraphs. For example, if the question was "Who is a good boy?" and the paragraph had stated that Will was a good boy, you should answer, "Will," and not give the name of some good boy of your acquaintance.

Read this and then write the answers. Read it again if you need to.

Lunde Rikardo vidis ruĝan vulpon, grizan sciuron kaj nigran serpenton en la arbaro. La sekvantan tagon li vidis brunan kuniklon kaj kvin brunajn musojn en la kampo. Li mortigis la vulpon kaj ĉiujn musojn sed permesis ke aliaj vivus.

1. Kio estis la nomo de la knabo kiu vidis la musojn? .....
2. Kiun tagon li vidis la musojn? .....
3. Kiun koloron havis la vulpo? .....

The time allowances were:

For 1 (vocabulary), 13 minutes, but if the individual needed more time he was permitted to work as long as he liked after the regular test program was completed.

For 2 (printed directions), 13 minutes, with the same privilege of unlimited time to work after the regular program was completed as with Test 1.

For 3 (directions given orally). Each direction was read once slowly and clearly. Then five seconds was allowed to make the response.

For 4 (paragraph reading), 13 minutes, with the same privilege as in 1 and 2.

In the test after learning the order of tests was 1, 3, 2, 4; instead of 1, 2, 3, 4.

With the exception of the final tests in experiments 5 and 6, all the tests were given by the same person and in a uniform manner.[1] They were all scored by the same person in a uniform manner.

Different experiments were conducted as follows:

Language Experiment 1. A group of fifteen college graduates ranging in age from twenty to fifty-two, spent twenty hours, ten in class and ten in individual study, in learning the artificial language, Esperanto. This work was done conscientiously by

[1] The final tests in experiments 5 and 6 were given by a competent person, the teacher of the class.

all as an educational experiment. Their interest varied greatly, but all had ten hours of class teaching[1] and we accept without reservation their statements that they studied faithfully for ten hours outside of class as directed.

Language Experiment 2. Thirty-three college or graduate students, sixteen of age 19 to 25, one of age 32 and sixteen of age 35 to 57, duplicated Experiment 1. They had perfect attendance records except two individuals for one hour each, and we have again full confidence in their statements that they did the individual study as directed. They had the same teacher as the group in Experiment 1.

Language Experiment 3. Twelve college undergraduates, ranging in age from twenty to twenty-three, studied Esperanto, but with a different teacher and for total times for class and individual study ranging from 7 to 17 hours.[2]

Language Experiment 4. Ten pupils, of age 14 years 5 months to 18 years 0 months (at the beginning of the course), were tested before and after 33 periods (23¼ hours) of class study and approximately 23¼ hours of home study of Esperanto under a regular teacher in a private school of excellent repute.

Language Experiment 5. Twelve pupils in Grade 4, of age 7 years, 11 months to 9 years, 9 months were tested (with tests 1, 2, and 3 only) before and after 13 hours of class study, in a private school of excellent repute. Their intelligence scores by the Dearborn Intelligence Examination varied from 96 to 139, averaging 113.

Language Experiment 6. Five pupils in Grade 5, of ages 9 years, 4 months to 10 years, 4 months, in the same school in which Experiment 5 was carried on, were tested before and after 19 hours of class study. Their intelligence scores by the Dearborn Intelligence Examination varied from 109 to 150, averaging 126.

Language Experiment 7. Ten pupils of age 10 to 12, with intelligence quotients of 137 to 173, and scores by the Stanford Educational Achievement Test, from 122 to 172, were tested

[1] If an individual was absent, he was given the instruction of the hour that he missed.

[2] For the records for Experiments 3 to 12 we are indebted to the International Auxiliary Language Association.

before and after a series of eighteen lessons of thirty minutes each, of which they attended fourteen on the average. No study outside of class was required, and probably there was little or none.

Language Experiment 8. Eight university students, of age 19 to 33, were tested before and after 4 or 5 hours of class instruction, plus from 0 to 6 hours of individual study, making totals of 4, 4, 4⅛, 4⅓, 5½, 6, 6, and 11 hours.

Language Experiment 9. Seven women, of age 28 to 69, were tested before and after from 6 to 9 hours of class study, plus from 0 to 35½ hours of individual study, making totals of 8, 8½, 9, 11¾, 14, 15½, and 44½ hours. No intelligence scores were obtained, but the subjects were probably equal or superior to the average college graduate in this respect.

We have also certain records of other adults learning Esperanto which are of some slight value. They are reported in Table 80, under the headings, Experiment 10, Experiment 11, and Experiment 12. In Experiment 12, the learners were instructed not to spend any time at all in study outside the class, and probably did not. In Experiment 10, records of how much they studied are not available. The instructor reports: "No outside study was required and probably little was done."

For reasons which do not concern us here, the test after the learning in Experiment 3 was delayed till 53 days after the last class exercise. The test after the learning in Experiment 1 was delayed till 25 days after the last class exercise. The intervals for the other experiments were as follows:

Experiment 2	1 day
" 4	1 "
" 5	1 "
" 6	1 "
" 7	2 days
" 8	7 "
" 9	7 "
" 10	0 "
" 11	7 "
" 12	2 "

Of the individuals in Experiments 1 to 12, only two had ever studied Esperanto before the experiments, according to the reports made to us. *Bur.*, age 32:2, and *Fle.*, age 36:1, of

Experiment 2, had studied it sixteen years previously "for 25 hours" and "off and on for two months," respectively. They gained a little less than the average for their age. It makes very little difference whether they are included in the measurements or excluded. We have included them.

Tables 75 to 80 present the data on age, intelligence, amount of study, initial score and gain in each test, the sum of the initial scores in Tests 2, 3, and 4, and the sum of the gains in Tests 2, 3, and 4.

TABLE 75

Age and improvement in learning a language: Language Experiment 1.

Individual	Age	Intelligence Score* *CAVD*	Hours of Study	Initial Scores				Gains				Initial 2+3+4	Gain 2+3+4
				1	2	3	4	1	2	3	4		
1	22	433	20	53	9	12	3	34	18	11	4	24	33
2	23	401	"	56	9	8	1	20	11	12	13	18	36
3	27	...	"	56	9	8	5	14	13	0	0	22	13
4	28	421	"	54	11	10	1	22	7	4	13	23	24
5	28	430	"	53	14	9	2	18	4	6	11	25	21
6	31	415	"	57	9	6	3	17	8	3	12	18	23
7	32	420	"	37	4	5	2	27	8	7	5	11	20
8	33	421	"	17	3	2	0	5	7	2	4	5	13
9	33	435*	"	38	9	8	4	31	12	4	7	21	23
10	34	430*	"	29	9	4	1	28	11	4	8	14	23
11	35	395	"	46	5	6	3	12	9	3	3	14	15
12	38	417	"	39	7	7	3	30	9	3	3	17	15
13	41	423	"	58	7	3	1	1	9	2	4	11	15
14	42	424	"	71	8	10	2	5	13	0	9	20	22
15	52	426	"	36	7	8	1	28	10	4	7	16	21

* Estimated from incomplete data.

TABLE 76

Age and improvement in learning a language: Language Experiment 2.

Individual	Age	Intelligence Score *CAVD*	Hours of Study	Initial Scores				Gains				Initial 2+3+4	Gain 2+3+4
				1	2	3	4	1	2	3	4		
16	20	402	19	34	11	2	0	25	10	5	6	13	21
17	20	411	20	41	10	6	4	25	7	7	1	20	14
18	21	436	"	68	18	7	6	18	7	12	12	31	31
19	21	419	"	69	16	11	2	12	8	7	13	29	28
20	22	413	"	60	14	4	6	22	8	9	11	24	28
21	22	410	"	75	16	10	5	6	4	7	10	31	21
22	22	420	"	72	20	14	9	10	6	6	9	43	21
23	22	412	"	64	10	4	2	17	14	16	13	16	43
24	22	430	"	76	26	16	13	9	−1	5	6	55	10
25	22	432	"	74	18	7	9	14	7	12	8	35	27
26	23	408	"	61	12	3	5	16	12	12	8	20	32
27	23	397	"	46	8	4	2	23	14	1	3	14	18
28	23	402	"	66	9	8	4	5	13	6	11	21	30
29	24	406	"	47	16	9	2	21	4	5	5	27	14
30	24	435	"	55	11	8	2	9	12	4	11	21	27
31	25	419	"	62	9	1	4	20	14	9	14	14	37
32	32	424	19	67	22	6	11	10	2	8	8	39	18
33	35	402	20	61	15	5	3	17	8	3	13	23	24
34	36	432	"	61	14	9	2	17	6	2	13	25	21
35	37	415	"	62	13	8	3	14	10	4	14	24	28
36	38	423	"	62	15	6	4	4	6	1	12	25	19
37	38	403	"	45	17	5	1	6	−1	0	7	23	6
38	38	414	"	59	13	4	2	15	12	5	13	19	30
39	39	424	"	72	17	7	4	18	10	1	12	28	23
40	40	406	"	49	5	3	1	7	14	3	9	9	26
41	40	434	"	57	16	5	2	32	6	2	16	23	24
42	42	412	"	60	7	3	0	5	4	−1	4	10	8
43	42	428	"	61	12	2	1	3	13	1	15	15	29
44	43	417	"	41	6	2	0	30	13	0	14	8	27
45	44	404	"	43	4	4	1	13	13	1	1	9	15
46	46	422	"	57	11	5	2	20	9	1	5	18	15
47	47	422	"	71	16	10	6	12	10	0	12	32	22
48	57	422	"	32	14	2	1	49	9	0	14	17	23

TABLE 77

Age and improvement in learning a language:
Language Experiment 3. College undergraduates.

Individual	Age	Intelligence*	Hours of Study	Initial Scores				Gains				Initial 2+3+4	Gain 2+3+4
				1	2	3	4	1	2	3	4		
49	20	89	12.75	67	16	12	8	21	10	6	8	36	24
50	20	77	13.25	82	21	15	9	7	4	3	8	45	15
51	21	77	13	63	14	12	5	19	9	2	7	31	18
52	21	82	12	56	11	6	4	24	13	5	11	21	29
53	20	98	13.75	63	16	11	5	24	11	5	12	32	28
54	20	60	7	80	13	12	10	8	12	5	3	35	20
55	20	89	9	60	15	9	7	24	4	6	2	31	12
56	22	90	11.5	68	14	14	4	2	6	3	8	32	17
57	20	97	13.25	70	18	11	8	12	5	9	7	37	21
58	21	86	13.75	73	16	14	6	7	7	7	11	36	25
59	20	60	17	76	14	14	5	9	8	5	6	33	19
60	22	93	8	78	13	10	3	3	11	3	9	26	23
Average			11.7	69.6	15.1	10.7	6.2	13.3	8.3	4.9	7.7	32.9	20.9

* The intelligence score is the percentile rank among freshmen at a college of very high grade. The 89 means that only 11% of the class were above individual 49. The 77 means that only 23% of the class were above individual 50.

TABLE 78

Age and improvement in learning a language: Language Experiment 4.

Individual	Age	Intelligence Score*	Hours of Study	Initial Scores				Gains				Initial 2+3+4	Gain 2+3+4
				1	2	3	4	1	2	3	4		
61	15:11		46½	53	4	2	2	7	9	3	7	8	19
62	14:9		"	48	6	1	4	5	3	5	1	11	9
63	14:5		"	70	20	13	10	7	3	5	0	43	8
64	17:5		"	45	3	1	2	19	5	1	0	6	6
65	15:8		"	43	3	2	3	9	5	3	−2	8	6
66	16:5		"	39	4	6	1	15	3	0	−1	11	2
67	16:7		"	46	2	2	4	5	6	5	0	8	11
68	16:0		"	34	5	4	1	4	5	0	2	10	7
69	18:0		"	59	15	11	14	15	9	7	2	40	18
70	15:11		"	51	5	4	5	8	8	4	−2	14	10
Average				48.8	6.7	4.6	4.6	9.4	5.6	3.3	0.7	15.9	9.6

* Individuals 61, 64, and 69 were in the last year of high school, grade 12.
Individuals 63, 65, 66, 67, and 70 were in grade 11.
Individuals 62 and 68 were in grade 10.

TABLE 79

Age and improvement in learning a language: Language Experiments 5, 6, and 7.

Individual	Age	Intelligence Score: Dearborn	Hours of Study	Initial Scores				Gains				Initial 2+3+4	Gain 2+3+4
				1	2	3	4	1	2	3	4		
Grade 4													
71	9:9	96	13	28	0	0		1	0	1			
72	8:7	108	"	25	0	0		20	1	2			
73	8:2	127	"	18	0	2		9	1	0			
74	7:11	139	"	19	0	1		3	4	0			
75	8:2	119	"	25	0	0		−5	0	2			
76	8:7	111	"	9	0	0		6	0	1			
77	9:8		"	39	0	0		12	8	3			
78	9:3		"	16	0	2		4	0	0			
79	8:9		"	28	3	1		3	−1	1			
80	9:8		"	20	0	2		7	1	0			
81	8:10		"	26	3	0		2	−3	2			
82	8:9		"	16	1	0		5	0	1			
Average for grade 4				22.4	0.6	0.7		5.6	0.9	1.1			
Grade 5													
83	9:4	122	19	23	0	1	2	14	4	4	0	3	8
84	9:10	109	"	24	1	2	0	8	2	0	2	3	2
85	10:4	110	"	23	3	0	0	−3	2	3	0	3	5
86	9:7	150	"	28	2	1	0	11	5	2	1	3	7
87	8:10	137	"	18	1	1	1	19	3	4	1	3	7
Average for grade 5				23.2	1.4	1.0	0.6	9.8	3.2	2.6	0.8	3.0	5.8

TABLE 79 — *Continued*

Age and improvement in learning a language: Language Experiment 4.

Individual	Age	Intelligence Score: Dearborn	Hours of Study	Initial Scores				Gains				Initial 2 + 3 + 4	Gain 2 + 3 + 4
				1	2	3	4	1	2	3	4		
				GRADES 6 AND 7, EXCEPTIONALLY GIFTED									
		I.Q.											
88	12	...	5.5	12	2	2	0	7	1	3	2	4	6
89	10	173	8.5	29	4	2	1	9	0	2	0	7	2
90	10	168	8	38	5	4	0	3	−3	0	2	9	−1
91	11	140	5	40	5	6	0	2	2	3	2	11	7
92	10	137	6.5	41	0	3	1	7	6	1	4	4	11
93	11	149	6.5	25	3	3	1	2	1	3	1	7	5
94	11	150	6.5	31	4	3	0	26	0	2	2	7	4
95	11	...	7	38	8	4	1	13	0	4	2	13	6
96	10	160	7.5	15	4	3	0	16	2	3	2	7	7
97	11	138	8	9	3	2	0	14	3	2	0	5	5
Average for exceptionally gifted				27.8	3.8	3.2	0.4	9.9	1.2	2.3	1.7	7.4	5.2

TABLE 80

Age and improvement in learning a language: Language Experiments 8, 9, 10, 11 and 12.

				EXPERIMENT 8									
98	19		6	60	12	8	1	17	7	4	5	21	16
99	19		4	66	13	9	4	9	9	6	11	26	26
100	23		11	68	13	9	3	11	7	0	9	25	16
101	23		4⅓	74	11	7	2	−3	8	4	7	20	19
102	24		5½	64	16	13	3	12	1	0	9	32	10
103	28		4¼	44	11	6	0	23	4	1	2	17	7
104	30		4	62	11	5	2	7	7	5	4	18	16
105	33		6	76	13	12	9	3	0	7	4	34	11

TABLE 80 — *Continued*

Age and improvement in learning a language: Language Experiments 8, 9, 10, 11 and 12.

Individual	Age	Intelligence Score	Hours of Study	Initial Scores				Gains				Initial 2 + 3 + 4	Gain 2 + 3 + 4
				1	2	3	4	1	2	3	4		
EXPERIMENT 9													
106	28		15.5	69	15	15	2	7	10	1	13	32	24
107	35		11.75	74	11	3	5	8	14	7	8	19	29
108	45		9	54	12	9	3	25	12	5	6	24	23
109	53		8.5	61	9	3	2	10	6	8	7	14	21
110	54		14	74	14	10	4	1	5	6	6	28	17
111	56		12	67	8	10	6	6	10	5	4	24	19
112	64		44.5	79	18	8	5	5	7	11	11	31	29
EXPERIMENT 10													
113	28		5	72	13	14	4	5	9	2	6	31	17
114	32		"	83	13	13	4	9	12	6	13	30	31
115	40		"	68	18	12	11	16	8	4	6	41	18
116	42		"	20	3	0	1	35	11	0	−1	4	10
117	44		"	66	19	14	3	30	7	3	15	36	25
118	48		"	48	13	10	7	24	12	1	9	30	22
119	48		"	79	15	16	5	2	9	0	9	36	18
120	50		"	73	13	9	7	9	12	−3	7	29	16
121	56		"	52	16	6	3	33	1	8	7	25	16
EXPERIMENT 11													
122	24		21	69	19	10	5	8	5	9	11	34	25
123	24		19	71	13	8	3	13	13	13	14	24	40
124	24		28	66	16	8	5	11	6	14	12	29	32
125	24		13	50	14	9	6	28	8	9	1	29	18
EXPERIMENT 12													
126	18		15	26	16	4	3	40	6	15	7	23	28
127	19		30	30	6	5	1	29	14	9	4	12	27
128	20		15	67	21	5	9	11	4	16	7	35	27
129	26		30	34	5	5	2	38	6	6	3	12	15
130	30		30	30	2	3	0	48	19	13	13	5	45

The facts of these experiments are very valuable, inasmuch as they are objective records of the influence of age on learning a highly logical and systematic body of knowledge.

Let us first consider the difference between ages 18 to 25, 26 to 34, and 35 or over, using the gain in Test 1, and the gain in Test 2, 3, and 4 combined, as our measures of gain.

Within Experiment 1 the conditions are alike for all. Two individuals of age 22 and 23, averaging 417 in Intelligence CAVD, 54.5 in initial score in 1, and 21.0 in initial score in 2 + 3 + 4, made average gains of 27 in 1 and 34.5 in 2 + 3 + 4. Eight individuals of ages 27 to 34, averaging approximately 422 in Intelligence CAVD, 42.6 in initial score in 1, and 17.4 in initial score in 2 + 3 + 4, made average gains of 20.3 in 1 and 20.0 in 2 + 3 + 4. Five individuals 35 or over, averaging 42 years old, 417 in CAVD, 50 in initial score in 1, and 15.6 in initial score in 2 + 3 + 4, made average gains 15.2 in 1 and 17.6 in 2 + 3 + 4.

Within Experiment 2 the conditions are alike for all. Sixteen individuals of ages 20 to 25, averaging approximately 417 in Intelligence CAVD, 60.7 in initial score in 1, and 25.9 in initial score in 2 + 3 + 4, made average gains of 15.8 in 1 and 25.1 in 2 + 3 + 4.

One individual of 32, scoring 424 in CAVD, 67 in initial score in 1, and 39 in initial score in 2 + 3 + 4, gained 10 in 1 and 18 in 2 + 3 + 4.

Sixteen individuals of ages 35 to 57, averaging 417.5 in CAVD, 56.4 in 1, and 19.3 in 2 + 3 + 4, made average gains of 16.4 in 1 and 21.8 in 2 + 3 + 4.

We may combine the facts from Experiment 1 and from Experiment 2 by making a reasonable allowance for the fact that the test in Experiment 1 was delayed until 25 days after the last period of class learning. An addition of 5, 10, or 15 per cent to the obtained gains will make them approximately what they would have been if the test had come within a day or two. Using 10 per cent, we have gains for the three age groups in tests 1, 2, 3, 4, and 2 + 3 + 4 as follows:

25 or under	18	17.3	9.5	8.2	8.9	26.6
26–34	9	20.9	8.8	4.6	8.2	21.6
35 or over	21	16.5	9.4	1.7	9.7	20.8

If we use a larger allowance, or if we combine without making any allowance for the delay in the test, the differences between the youngest group and the oldest group are nearly the same as these. It is only the group of age 25 to 34 that is altered appreciably in relation to the others by the allowance. The results when no allowance is made are as follows:

Under 25 . .	18	17.0	9.3	8.1	8.8	26.2
25 to 34 . .	9	19.1	8.0	4.2	7.6	19.8
35 and over .	21	16.2	9.2	1.6	9.6	20.4

It is noteworthy that the youngest and oldest group are almost alike except in Test 3, the oral directions. How far this concentration of difference in this one aspect of the learning is due to some essential age difference, and how far it is due to less amount of attention and home study being given to oral work by the older group, is not known.

We may combine gains in 1, 2, 3, and 4 into a single score measuring general gain, if we can decide upon the relative importance of the abilities tested by 1, 2, 3, and 4. So far as old *versus* young is concerned, the result will be nearly the same by any weighting of 1, 2, and 4; 3 is the only one of much influence. Opinions will naturally differ. Using the average of five intelligent persons, of whom two were experts in psychology and three were well trained in English, all of whom had studied Esperanto and knew the tests, we have 41, 50, 60, and 61 as comparative weights. If we use three-tenths of the gain in 1, plus nine-tenths of the gain in 2, plus eleven-tenths of the gain in 3, plus the gain in 4, we shall have weighted the four tests in the proportions of 40, 50, 62, and 59. (Their respective variabilities are 9.98, 4.10, 4.14, and 4.35.)

Doing this, we have the following weighted total gains for the three groups:

Using the allowance of 10% for late testing	31.7	for those 25 or under
	27.5	" " 26 to 34
	25.0	" " 35 or older
Using no allowance	31.2	for those 25 or under
	25.1	" " 26 to 34
	24.4	" " 35 and over

The difference (of 6.7 or 6.8 according to the method used)

between the youngest and oldest group is not large in comparison with the amount of gain or in comparison with its own unreliability. The mean square errors of the 31.2, 25.1, and 24.4 above are respectively 2.1, 2.0, and 1.8. There are then 68 chances in 10,000 that the true difference between the group under 26 and the group of 35 or over is really zero, and the same chances that it is really 13.6. The chances are even, that it is between 5.1 and 8.5. The reliability for the facts with the 10% allowance will be approximately the same.

In all cases of learning, it is wise to examine the data to ascertain whether differences in the initial ability may account for some of the differences in gain. In the present case the 19 to 25 group make considerably higher initial scores in 2 + 3 + 4 than the 35 and over groups. There is, however, within either group a low correlation of initial score in 2 + 3 + 4 with gain in 2 + 3 + 4.

The scanty results from Experiments 8, 9, 10, and 12 agree with those from Experiments 1 and 2 in indicating that deterioration with age is confined to the learning tested by 2, 3, and 4, and that it is small even there. The older groups in these experiments make greater gains than the young in 1, and smaller gains in 2 + 3 + 4. In Experiment 8, if we omit the person who studied 11 hours, four individuals under 25 averaged 4.95 hours of study, 66 and 24.8 as initial scores (in 1 and in 2 + 3 + 4, respectively) and 8.8, 6.3, 4.7, and 8.0 as gains. Three individuals 26 to 34 averaged 4.75 hours of study, 60.6 and 23 as initial scores, and 11.0, 3.7, 4.3, and 3.3 as gains. The total gain using weights in the proportions 40, 50, 62, and 59, was 21.5 for the young group and 14.7 for the old.

In Experiment 12, one nineteen-year-old gained 29, 14, 9, and 4 from 30 hours of study whereas two individuals of age 26 and 30 made average gains of 43, 12.5, 9.5, and 8. The weighted totals are 35.2 and 42.6.

Combining the results for Experiments 8 and 12, with twice as much weight attached to 8 as to 12, we have 26 and 24 for the weighted average gain of those under 25 and those 26 to 34.

In Experiment 9, if we omit the person who studied 35½ hours outside of class, two individuals from 25 to 35 compared with four individuals 45 or over show the following averages:

	Initial Scores			Gains			
	Time	1	2+3+4	1	2	3	4
25–35 . .	13.6	71.5	25.5	7.5	12	4	10.5
45 and over	10.9	64.0	22.5	10.5	9.5	6	5.75

The total gain, using weights in the proportions of 40, 50, 62, and 59, is 28 for the younger group and 24.1 for the older.

In Experiment 10, if we assume that the two younger did not differ from the seven older appreciably in the amount of study, we may compare averages as follows:

	Initial Scores		Gains			
	1	2+3+4	1	2	3	4
26–35 . . .	77.5	30.5	7.0	10.5	4.0	9.5
35 or over . .	58.0	28.7	21.3	8.6	1.9	7.4

The total gain, using weights as above, is 25.5 for the younger and 23.6 for the older.

Combining the results for Experiments 9 and 10, allowing equal weight to each, we have as average gains:

For those 25–34 . . . . . 26.8
For those 35 or over 23.9

The best available present knowledge then indicates that from age 25 on to 40 there is no falling off in the ability measured by the gain in Test 1, and that the individuals around 40 learn the matters tested by gain in Tests 2 + 3 + 4 nearly as well as individuals of age 22 or 23. If we may assume that on the average the change from 20 correct responses to 25 in 2 + 3 + 4, is as great a change as that from 25 to 30, and that each is as great as that from 30 to 35, and so on within the limits of 20 to 60, we may set the learning ability at age 40 as approximately 80 per cent of that at 22.

Consider now the learning of adults in comparison with that of children. In Experiment 4, ten pupils, 14 to 18, in a good

private school after 31 lessons of ¾ hours each, with a requirement of an equal amount of outside study, showed averages as follows:

Initial Scores		Gains	
1	2 + 3 + 4	1	2 + 3 + 4
48.8	15.9	9.4	9.6

Their initial scores are about the same as those of the adults 35 or over in Experiments 1 and 2, but their gains are only about half as great, though they had over twice as much time in class, and outside of class if they did not shirk their work.

In Experiment 6, five pupils of good intelligence, aged 8 to 10, had 19 hours of instruction. Their average gains were 9.8 in 1 and 5.8 in 2 + 3 + 4, very much below what was gained by the adults of 35 and over in Experiments 1 and 2.[1]

The children in Experiment 5 with 13 hours of class study, and in Experiment 7 with about 7 hours, also gained very much less than the adults who had somewhat nearly the same amount of class study in Experiments 8, 9, 10, and 12. The children in Experiment 7 were abler intellects for their age than the College girls of Experiment 3 were for their age, or than the members of any other group were for their age. But they

[1] It should be kept in mind that these comparisons concern *gains* — differences between scores in tests before the study and scores in the same tests after the study. If we assumed that both young and old started with zero ability in Esperanto and compared them simply by what they could do at the end, the superiority of the old group to the group of age 9 or 11 would be much greater. For example, the record in the final test for the group of five children 8 to 10 years old with 19 hours of class instruction, and for the sixteen individuals 35 years old or over of Experiment 2 with 10 hours of class and 10 of home study, were:

	Score in Vocabulary	Score in Tests 2, 3, and 4
8–10	33.0	8.8
35 or over	72.8	41.1

learned very much less Esperanto per hour than the adult groups.

These experiments thus add strong evidence to the general body of fact showing that childhood is inferior to the twenties and thirties in many features of learning.

All the evidence points to a curve for ability to learn a systematic logical language with a vocabulary based largely on Latin, French, German, English, and Italian, of the following type for individuals who attend school through college: Rising from 8 to 16 and probably to 20, or later, then remaining parallel to its base line to 25 or later, then dropping very, very slowly to 35, and somewhat more rapidly, but still very slowly, to 45 or later.

APPENDIX V

Data and Procedures for Comparing the Learning of Adult Prisoners with That of Children

We are to compare the men's learning of school material with children's learning. Table 81 gives the necessary facts about children's learning. The gains made by the men were expressed as multiples of children's monthly gains. The first three columns of Table 82 simply summarize the facts about the men; that the 86 men tested in reading made an average initial score of 39.9 and an average gain of .5 for the whole period, etc. In the fourth column are estimated norms with which to compare the gains listed in the third column. For instance, the .6 given for reading was obtained by consulting Table 81

TABLE 81

Public school grade norms for the tests used.

	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Reading	30.0	37.3	41.8	48.0	53.7	58.3	60.9	62.1	63.6	65.4	68.1
Vocabulary			24.0	33.0	43.0	52.0	58.0				
Spelling	5.0	7.6	10.5	12.5	14.5	16.4	18.3	20.0			
Composition	3.0	3.6	4.2	4.7	5.3	5.2	5.9	6.3	6.7		
Writing	8.3	9.3	10.1	10.8	11.4	12.0	12.5				
Addition		9.5	12.3	13.7	15.3	16.4	17.0				
Subtraction		7.3	9.3	10.7	12.6	13.7	14.2				
Multiplication		5.9	10.4	11.6	14.6	15.9	17.2				
Division		4.6	7.2	8.4	10.6	11.9	13.0				
Problems (Monroe Test I)			11.3	19.2							
Problems (Buckingham, Div. I, II, and III)		39.0	45.0	61.0	66.0	80.0	84.0				

to see between what norms the men's average initial score falls. It is between the 37.3 for Grade III and the 41.8 for Grade IV. The increase from Grade III to Grade IV (41.8–37.3) equals 4.5. The interval to the left is 7.3 and the one to the right is 6.2. The average of these three yearly increments

is 6.0 and is taken as the best single measure of a year's improvement in Thorndike-McCall Reading Test score for a group of children making the same initial scores that the 86 men did. This value divided by 10 gives the .6 which is listed in Table 82 as a normal children's gain for a school month. The other figures in the fourth column were with minor exceptions obtained in the same way.

In the main, the increments from year to year in Table 81 do not vary greatly throughout the range in which we are making comparisons. If they had varied a great deal, it would have been advisable to divide the men into groups according to initial score or to have left them as classified in school, to permit comparison of the reading gains of the men of low initial score with the reading gains of children of low initial score. Under the circumstances it was considered sufficiently accurate to compare the entire group with a single norm.

The last column of Table 82, was obtained by dividing the men's gain by the children's monthly gain in the same test.

TABLE 82

Data used with Table 81 in expressing men's gains as multiples of children's monthly gain.

	Number of Men Measured	Men's Average Initial Scores	Men's Average Gains for Whole Period	Figures Chosen from Table 81 as Normal P. S. 4-Week Gains	Men's Gains in Terms of P. S. Children's Monthly Gains
Reading	86	39.9	.5	.6	1
Vocabulary	60	38.8	3.0	.9	3
Spelling	68	12.0	1.4	.2	7
Composition	59	3.4	1.5	.06	25
Writing	79	9.2	1.3	.08	16
Addition	23	9.6	1.2	.28	4
Subtraction	38	8.9	.4	.16	3
Multiplication	56	9.4	2.4	.12	20
Division	34	6.1	2.0	.14	14
Arithmetic Problems (B)	34	55.2	5.3	.9	6
Arithmetic Problems (M)	35	22.6	6.2	.8	8

The quotient is reported to the nearest whole number. *One*, in the first line, means that in reading the men gained in the whole period about as much as children gain in a school month. According to the second line, in vocabulary, they gained about as much as children gain in three months.

In Table 83, we have placed the last column of Table 82 alongside of the lengths of the learning period. These were

TABLE 83

Men's school learning compared to normal increases in public schools. Seventy-seven of the 118 men were originally in Standards III and IV.

KIND OF LEARNING	LEARNING PERIOD IN SCHOOL MONTHS (4 weeks each)	AMOUNT OF LEARNING EXPRESSED AS THE NUMBER OF SCHOOL MONTHS IT TAKES PUBLIC SCHOOL CHILDREN TO MAKE THE SAME INCREASE
Reading	11	1
Vocabulary	11	3
Spelling	9	7
Composition (in letter writing)	12	25
Writing	12	16
Addition	12	4
Subtraction	12	3
Multiplication	12	20
Division	12	14
Arithmetic Problems	9	7
Averages (weighted by the number of men tested in each case)	11	9

obtained from the last column of Table 9 by dividing by four and recording the quotient to the nearest month. The first line of the table should be read as follows: In eleven months the men increased their Thorndike-McCall Reading Test scores by the amount that children's scores are increased in one month. The last line means that in the ten kinds of learning measured, the men learned on the average in eleven months what children learn in nine, or in other words they made 82 per cent of the progress made by children.

But the children's school day is four times as long as the men's. Even though their five-hour day is not so fully devoted to the kinds of learning measured as is the men's, the men's learning per hour of instruction undoubtedly equalled or exceeded the progress made by children.

The differences in the second column of Table 83 are not entirely chance differences. The probable error of the one month for reading is one and one-half months; that for composition is two months. The twenty-four months' difference between the gains in reading and composition is therefore between nine and ten times its probable error.

The differences are in part due to differences in emphasis in curricula and to differences in emphasis and efficiency in teaching in the adult school. It is in entire accord with our observations to find at the top of the list the gains in handwriting, quality of composition in letter writing, multiplication, and division.

However, we cannot conclude that these subjects were overemphasized in the teaching of the men. It is quite conceivable that the results may be due to differences of emphasis in the public schools. Take for instance reading and composition in the fourth grade. The time spent in the teaching and practice of reading may be far greater than the time spent on composition. Assume that such is the case and also that the men had equal amounts of instruction and practice in reading and composition. Differences such as those listed in Table 83 would result without the operation of any differential effect of age upon the capacity to learn different kinds of subject matter.

We cannot, therefore, draw any conclusions from Table 83 as to such a differential effect without taking into account time spent in instruction and practice upon each subject, both in the men's school and in common public school practice. This we cannot do with any precision, but in our opinion such a comparison would materially iron out the variability in the obtained results.

APPENDIX VI

The Technique of Partial Correlations

The use of correlations to measure the changes in ability to learn which accompany age needs some explanation for those who are not versed in the theory of mental measurements.

The natural and straightforward method of measuring the the influence of age upon ability to learn is to secure groups alike in every respect except age and ability to learn, and to compute directly how much difference there is in ability to learn between those 15 years old and those 16 years old, between those 16 years old and those 17 years old, and so on. It is, however, almost impossible to obtain groups which are known to be alike in all respects save age and ability to learn. The older ones may be brighter or duller; they may have a better or worse initial status in the thing which is being learned; they may give more or less attention to the work of learning.

The technique of partial correlations is a means of estimating what the relation between age and ability to learn would be if certain other factors were equalized or kept constant. For example, suppose that we have measures in the case of a thousand men of: *a*, age; *s*, success in learning in a special school for adults; *i*, score in an intelligence test.

Suppose that the facts for *s* and *a* are as shown in Table 84. At their face value, the facts of Table 84 show a marked loss in ability to learn with age. The correlation is $-$ .50 with age or $+$ .50 with youth. This may be misleading. If success in learning goes with intelligence as shown in Table 85, and if the older persons are duller as shown in Table 86, it may well be that, in a group all of identical intelligence scores, the older would succeed in learning nearly or quite as well as the younger.

The correlation of *s* with *i* shown in Table 85 is $+$ .80. The correlation of *a* with *i* shown in Table 86 is $-$ .60. The correlation of *a* with *s* shown in Table 84 is $-$ .50. From these

facts we can calculate what the relation of s to a would be for a group alike in i. It would be $-$ .04, or approximately as shown in Table 87.[1]

It is customary to use the following notation in such cases:

r, the coefficient of correlation, means the general drift of a diagram like Tables 84, 85, 86, and 87.

r_{as} means the correlation between age and success in learning, $-$ .50 in our illustration.

r_{ai} means the correlation between age and intelligence score, $-$ .60 in our illustration.

r_{si} means the correlation between success in learning and intelligence score, $+$ .80 in our illustration.

$r_{as \cdot i}$ means the correlation which would be found between age and success, if only individuals identical in intelligence score were used, $r_{as \cdot i} = -$ .04 in our illustration.

More than one factor can be thus equalized, or made identical. Thus, if l represents the length of previous schooling, $r_{as \cdot il}$ will mean the relation between age and success in learning which would be found for a group identical in intelligence score and length of previous schooling.

The actual meaning of an r between age and learning after equalization for intelligence or the like, in terms of how much difference in ability to learn one year or two years or ten years of age involves, depends on the range or spread or variability of the ages in question and of the degrees of ability to learn in question. Thus, in the case of the $r_{as \cdot i} = -.04$ of our illustration, the decrease due to one year of age is about one thousandth of the difference between the ability to learn of the average man of age 21 and that of the best learner of age 21. In general an r for age with ability to learn which is between $-$ .15 and $+$ .15 will mean for such groups as will be reported here a very, very small decrease (or increase if r is plus) of ability to learn per year.

[1] The correlation plots of Tables 84 to 87 are for illustration only and are not to be used as precise correlation tables for .50, .80, .60, and 0 respectively. They are probably close approximations to precise tables but we have not verified them in detail.

TABLE 84

A correlation of − .50 between age and success in learning. Each entry of the table gives the number of individuals of a given age and degree of success in learning.

Success in Learning → \ Age in Years →	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54
41		1	1	2	2	3	2	1	1									
40	1	2	4	8	11	14	13	10	7	3	1	1						
39	1	4	10	21	35	49	53	49	35	22	11	4	1					
38	1	5	15	35	67	107	138	145	124	87	49	23	8	2	1			
37	1	4	14	36	85	157	231	281	278	231	147	78	34	12	4	1		
36		2	8	26	68	145	251	352	401	373	281	169	88	36	12	3	1	
35		1	3	12	36	88	169	281	373	401	352	251	145	68	26	8	2	
34			1	4	12	34	78	147	231	278	281	231	157	85	36	14	4	1
33				1	2	8	23	49	87	124	145	138	107	67	35	15	5	1
32						1	4	11	22	35	49	53	49	35	21	10	4	1
31							1	1	3	7	10	13	14	11	8	4	2	1
30										1	1	2	3	2	2	1	1	

TABLE 85

A correlation of + .80 between intelligence and success in learning. Each entry of the table gives the number of individuals of a given intelligence and degree of success in learning.

Success in learning → \ Intelligence score →	340	350	360	370	380	390	400	410	420	430
42									1	1
41							1	4	5	2
40						1	13	33	19	2
39					1	23	109	115	28	1
38				1	22	196	383	172	18	
37				12	192	696	578	110	4	
36			3	104	691	1058	373	29		
35			29	373	1058	691	104	3		
34		4	110	578	696	192	12			
33		18	172	383	196	22	1			
32	1	28	115	109	23	1				
31	2	19	33	13	1					
30	2	5	4	1						
29	1	1								

TABLE 86

A correlation of − .60 between age and intelligence. Each entry of the table gives the number of individuals, out of 10,000 of a given age and degree of intelligence.

Intelligence → \ Age →	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52	54
430		1	1	1	1	1	1											
420	1	3	7	12	14	15	11	7	3	1								
410	2	7	18	39	65	88	90	72	47	24	10	3	1					
400	1	6	20	55	119	210	289	302	255	173	91	37	12	3	1			
390		2	9	31	90	201	360	506	564	494	339	172	77	27	7	1		
380			1	7	27	77	172	339	494	564	506	360	201	90	31	9	2	
370				1	3	12	37	91	173	255	302	289	210	119	54	20	6	1
360						1	3	10	24	47	72	90	88	65	39	18	7	2
350									1	3	7	11	15	14	12	7	3	1
340												1	1	1	1	1	1	

TABLE 87

A correlation of 0 between age and success in learning in the case of individuals, all alike in intelligence (Scores of 390).

Success in learning → \ Age →	24	26	28	30	32	34	36	38	40	42	44	46	48	50	52
39		1	2	6	10	14	16	14	9	5	2	1			
38	2	7	21	47	84	118	131	115	79	40	18	6	1		
37	7	27	75	169	301	424	472	415	284	145	65	22	5		
36	11	40	114	258	460	648	722	633	434	221	99	33	7		
35	7	27	75	169	301	424	472	415	284	145	65	22	5		
34	2	7	21	47	84	118	131	115	79	40	18	6	1		
33		1	2	6	10	14	16	14	9	5	2	1			

APPENDIX VII

The Relation of Ability to Learn to Age in Adult Prisoners

The Derivation of the Composite Scores

To have studied the data for each test for the entire group to which it was given would have meant the combination of heterogeneous groups and the introduction of errors which could not be corrected by the technique of partial correlations. For instance, the correlation between gain in multiplication and age was high because the third standard with a higher average age made more progress than the fourth. The correlation between age and gain in addition was low because Standard II with a lower average age gained more than Standard I did. In other words, varying opportunities for learning made it necessary to study the first-period gains separately by standards. To have studied the data separately also for each test used would have entailed a tremendous amount of labor. It would have meant 41 groups, with 6 "total" coefficients and 4 partials for each. To reduce the labor involved, the gain made by any individual in any school ability was expressed as his deviation from the average gain of the group tested in that ability in the ability in question, divided by the variability (mean square deviation) of the group in question in the ability in question. All the gains of any one individual after being so expressed, were averaged to form his composite score.

In some groups, the inclusion of both American and foreign-born was no more permissible than the inclusion of different standards. Some of the groups which were about equally American and foreign-born, we separated; namely, Standards III and IV for first-period data, and Standard IV for the study of addition practice. These, with the American-born in the substitution practice, make nine homogeneous groups. Most of the remaining groups are either predominantly American or predominantly foreign-born.

The Results

The correlations between age and learning with intelligence and initial score rendered constant are presented in Table 88; the results when only initial score is rendered constant are also

Table 88

Correlations between age and learning with intelligence and initial score rendered constant and with only initial scores rendered constant. P. E.'s range from ± .09 to ± .14.

Standard	Kind of Learning	Number of Men	Mean Age in Years and Mos.	S. D. of Ages in Years and Mos.	American or Foreign Born	Correlation* $r_{12.34}$	Correlation* $r_{12.4}$
I of 1st term	Composite of school learning — 1st period	23	36:9	8:5	96% F	−.03	−.14
II	Composite of school learning — 1st period	32	33:7	7:10	78% F	−.13	−.21
III	Composite of school learning — 1st period	23	27:11	8:0	A	−.36	−.29
III	Composite of school learning — 1st period	34	33:8	7:11	F	−.08	−.21
IV	Composite of school learning — 1st period	57	26:9	7:2	A	−.06	−.06
IV	Composite of school learning — 1st period	32	31:2	8:3	F	−.15	−.16
V	Composite of school learning — 1st period	28	24:7	4:7	89% A	−.22	−.19
VI	Composite of school learning — 1st period	37	25:1	4:6	76% A	−.11	−.12
III	Composite of school learning—whole period	35	31:0	8:3	54% F	−.22	−.26
IV	Composite of school learning—whole period	42	29:1	8:5	62% A	−.11	−.16
IV of 2nd term	Addition exs. done in 4 minutes	26	26:9	5:4	A	+.01	+.07
	Addition exs. done in 4 minutes	25	32:8	8:7	F	−.05	−.20
	Addition exs. right in 4 minutes	26	26:9	5:4	A	−.02	+.03
	Addition exs. right in 4 minutes	25	32:8	8:7	F	−.06	−.27
IV of 1st term	Knowledge of a code used in a substitution exp.	59	26:9	7:1	71% A	−.02	+.05
	Rate of substitution	54	27:11	7:4	76% A	−.13	−.12
	Rate of substitution	41	24:5	3:7	A	−.07	−.04

* 1 = Age 2 = Gain 3 = Intelligence 4 = Initial

presented in Table 88; the "total" coefficients from which they were computed are given in Table 89; the reliabilities of the measures used are shown in Table 90.

TABLE 89

Total coefficients from which the partials of Table 88 were computed.
1 = Age 2 = Gain 3 = Intelligence 4 = Initial

		r_{12}	r_{13}	r_{14}	r_{23}	r_{24}	r_{34}
Standard I	1st period composite	−.11	−.18	−.02	−.11	−.53	+.74
II	1st period composite	−.08	−.23	−.18	+.21	−.52	+.44
III	(Amer.-born) 1st period com.	−.29	−.45	−.27	−.06	+.04	+.54
III	(For.-born) 1st period com.	−.06	−.50	−.38	.00	−.31	+.76
IV	(Amer.-born) 1st period com.	−.06	−.06	−.06	−.01	+.04	+.49
IV	(For.-born) 1st period com.	+.11	−.42	−.59	−.13	−.38	+.67
V	1st period composite	−.18	+.13	+.02	+.18	−.30	+.12
VI	1st period composite	−.10	−.09	−.06	−.01	−.23	+.52
III	Whole period composite	−.24	−.29	−.24	+.19	−.06	+.68
IV	Whole period composite	−.15	−.24	−.18	+.12	−.06	+.57
Addition practice—American-born—no. done		+.09	−.41	−.17	−.15	−.13	+.01
Addition practice—American-born—no. C		+.03	−.41	−.16	−.12	+.02	+.09
Addition practice—Foreign-born—no. done		−.19	−.43	+.02	+.37	+.16	+.21
Addition practice—Foreign-born—no. C		−.20	−.43	+.12	+.51	+.41	+.22
Rate of substitution (American-born)		−.05	−.16	−.03	+.02	+.35	+.51
Rate of substitution (American-and Foreign-born)		−.16	−.33	−.23	+.10	+.22	+.66
Knowledge of code used		−.07	−.26		+.18		

When the partial coefficients of Table 88, are arranged in the order of their magnitude, the mid-value is − .08, and this we have taken as representing in general the correlation between age and learning for this group. The mid-value for the groups separated into American-and foreign-born is − .06; for those not separated − .12; the total r_{12} coefficients in Table 89, have a mid value of − .10.[1]

[1] There are certain apparent slight discrepancies between the facts of Table 13 of Chapter V and Column I of Table 89 of this appendix, which deal in the main with the same data. The r_{12} correlations are more uniformly negative than one would off-hand expect from Table 13. There is, however, no error or antagonism. The apparent discrepancies are due in part to the fact that the gain used in Table 13 is not always the same gain that was used in the correlations, the average of two early periods and the average of two late periods being sometimes used in the latter. For the rest they are due to extreme deviations having more weight in the correlations than in the group averages.

TABLE 90

RELIABILITIES OF MEASURES USED

The values given for the standard test scores are the correlations between the two forms used for the final test.

	N	*r*
Age (Prison record compared with test data)	169	.97
Pintner, Non-Language Mental Test Score	103	.92
Thorndike-McCall, Reading	108	.89
Thorndike Vocabulary	82	.88
Trabue's 25 words from Ayres & Buckingham	69	.86
Thorndike Handwriting (average judgment of 2 judges)	113	.70
Nassau Composition (average judgment of 2 judges)	71	.76
Woody, Addition	32	.81
Woody, Subtraction	52	.80
Woody, Multiplication	73	.75
Woody, Division	42	.53
Buckingham, Arithmetic Problems	31	.81
Monroe, Arithmetic Problems	40	.82
Whole period composite initial score	118	.91
Whole period composite final score	118	.95
Whole period gain in composite score	118	.53
Addition practice — initial number of examinations done	55	.97
Addition practice — gain in number of examinations done	55	.83
Addition practice — initial number of examinations right	55	.97
Addition practice — gain in number of examinations right	55	.75
Rate of substitution — first day initial	68	.93
Rate of substitution — first day final	68	.94
Rate of substitution — first day gain	68	.65
Knowledge of code at end of first day	61	.95
Knowledge of code 1 week later	58	.89
Rate of substitution after the week's interval	68	.95
Effect of the interval on rate (Rates after the week minus first day final)	68	.61
Rate of reverse substitution	54	.96
Transfer in reverse substitution (Rate of reverse substitution minus rate after week)	54	.58
Rate using the new code	54	.96
Transfer first code to new code (Rate with new minus rate after week)	54	.91

The Error in Correlations of Initial or Final Score with Gain which is Due to Chance Inaccuracies in the Scores

When an initial score or a final score is correlated with the gain (or difference between them), any chance error in the scores unduly lowers the former correlation and raises the latter. In our results this error is large in the "total" coefficients of correlation between initial and gain, but it is small in our final partial coefficients between age and gain with intelligence and initial rendered constant. According to our estimates this error is rarely more than 3 points in the second decimal place. The direction of the error varies in the partials of the second order according to the combination of signs in the partials of the first order. For one group, the 41 American-born men in substitution practice, we computed $r_{12.34}$ twice, using initial scores in one case and the average of initial plus final score in the other. Using initial, $r_{12.34} = -.05$. Using instead the average of initial plus final, it is $-.07$. Since the error is small and of varying sign, the mid-value of all the results for $r_{12.34}$ is but slightly affected by it.

The Influence of Inequalities in Units

Another factor which needs to be considered is the difference in the ease or difficulty with which a unit of improvement may be made at the different levels of ability. A tendency for the true values of steps treated as equal to be progressively larger or smaller as one moves up the scale would vitiate our procedure in allowing for differences in initial ability by partial correlation. Irregular differences in the units are of little consequence for our purposes.

There are probably no important errors from this source in the correlations we have reported. The practice curves in addition and in substitution show no evidence of rapidly changing value of the units. Inequalities in units are small and irregular throughout the ranges of ability measured by us in all of the tests used for elementary school subjects.

The Influence of Attitude and Effort

In order to evaluate the part played by interest and effort in producing these results, we had each teacher for each of his sections make a list of his men, placing at the top the one who was the most consistent worker and most anxious to learn, then the next best, and so on down to the least. The teachers were cautioned to disregard accomplishment, that is, to consider interest and effort only. The correlation between age and the decile rankings for good attitude for 271 men is $+ .08 \pm .04$; with intelligence rendered constant, it is $+ .12 \pm .04$. Therefore, the negative correlations found for school learning were obtained with attitude slightly favoring the learning of the older men.

This advantage probably operated in the addition practice also, for it was conducted by the Standard IV teacher as a part of the regular school work. But in the substitution experiment there were no evidences of lack of interest except on the part of the one or two for whom "trouble at home" was the all-engrossing thought. The men all seemed to try hard to better their score of the preceding three-minute period. Some of them, we learned later, thought they were learning shorthand, but whatever they thought they were doing, they all seemed to enjoy their gains. The progress which they made is, we believe, closely indicative of their capacity for this sort of learning.

In Standard IV six weeks later, we obtained a second listing of the men for attitude. The teacher was asked not to consult former lists if he still had them, because we wanted an independent ranking. The coefficient of correlation between decile ranks in the two lists (obtained by using Spearman's rank difference formula and substituting for R) averaged .80 (.78, .84, and .79 in the three sections). We had reason to credit the teacher with the ability to rank the men well; for we had him rank his men for intelligence before they had been tested and his ranks for intelligence correlated with Pintner scores in his three sections to the extent of .61, .32, and .57.

Using the average decile rank in attitude as our measure, the foreign-born showed a better attitude toward their school work than did the American-born. For the 57 American-born

in Standard IV the correlation between age and good attitude is + .14 ± .09 and for the 32 foreign-born in Standard IV it is − .07 ± .12. The *P. E.*'s are so large that the difference is not significant, but if our measure of attitude were rendered constant the correlation between age and gain in Standard IV of − .06 for native born would be made a little more negative, and the correlation of − .15 for the foreign-born would be made a little less so. The average of − .10½ for the two groups would remain very closely the same.

We have not partialled out attitude in each of the separate experimental groups, because it seemed wasteful, and because the populations scored for attitude were not identical with those in the experimental groups. Instead, we have taken thirteen groups (all those of Tables 88 and 89 except the two additions with number done, the substitution with American-born only, and the knowledge of the code) and found the median r_{12}, the median r_{13}, the median r_{14} and so on, as shown in Table 91. As r_{15} we have used the + .08 obtained as stated

TABLE 91

The total correlations used in deriving the partial correlations of Table 92. 1, 2, 3, 4, and 5 refer to age, gain, Pintner score, initial score, and attitude score respectively.

	2	3	4	5
1	−.10	−.24	−.16	+.08
2		.00	−.06	+.18
3			+.52	+.05
4				+.21

above. We have computed r_{25} for 105 individuals who had records of whole-period gains and for 271 individuals who had records of first-period gains. The results are + .22 and + .13 respectively; and we use + .18. As r_{35} we have + .05, obtained from the records of the 271 men. We have computed r_{45} in six groups, as shown below, and used + .21.[1]

24 adults in Standard I, r_{45} = + .25
30 adults in Standard II, r_{45} = + .09

[1] We use 5 as the symbol for attitude in all these correlations.

52 adults in Standard III, $r_{45} = +.31$
87 adults in Standard IV, $r_{45} = +.22$
28 adults in Standard V, $r_{45} = +.40$
39 adults in Standard VI, $r_{45} = .00$

We have computed $r_{12 \cdot 345}$ from these r's of Table 91. It is $-.13$. Some of the other partial correlations are of interest; so we report them in Table 92.

TABLE 92

The partial correlations computed from medians of the total correlations among age, gain, Pintner score and initial score, and from correlations between attitude and age, gain, Pintner score and initial score obtained from various data.

1 = age; 2 = gain; 3 = Pintner score; 4 = initial score in the thing learned; 5 = attitude score.

12	−.10	23	.00	34	+.52	45	+.21
12.3	−.10	23.1	−.02	34.1	+.50	45.1	+.23
12.4	−.11	23.4	+.04	34.2	+.52	45.2	+.22
12.5	−.12	23.5	−.01	34.5	+.52	45.3	+.22
12.34	−.11	23.45	+.05	34.12	+.50	45.12	+.25
12.35	−.12	23.145	+.03	34.125	+.50	45.13	+.22
12.45	−.14					45.23	+.23
12.345	−.13					45.123	+.24
13	−.24	24	−.06	35	+.05		
13.2	−.24	24.1	−.08	35.1	+.07		
13.4	−.19	24.3	−.07	35.2	+.05		
13.5	−.25	24.5	−.10	35.4	−.07		
13.45	−.18	24.13	−.08	35.12	+.08		
13.245	−.17	24.135	−.12	35.124	−.06		
14	−.16	25	+.18				
14.2	−.17	25.1	+.19				
14.3	−.04	25.3	+.18				
14.5	−.18	25.4	+.20				
14.23	−.05	25.13	+.19				
14.235	−.08	25.134	+.21				
15	+.08						
15.2	+.10						
15.3	+.09						
15.4	+.12						
15.23	+.12						
15.234	+.13						

It may be repeated here that we do not know how far the association of high attitude score with high initial ability and high gain is due to the fact that attitude has produced the gain and the past gains which initial ability measures, and how far it is due to an illusion or confusion whereby the teachers improperly attributed good attitude to the men who did well and improved rapidly. In so far as the latter happened, the − .13 for $r_{12 \cdot 345}$, the − .14 for $r_{12 \cdot 45}$ and the − .12 for $r_{12 \cdot 35}$ are too large negative correlations.

Partialling Out the Intelligence Test Score

To anybody who defines intelligence as learning capacity, partialling out the Pintner test scores will seem to be a serious source of error. He will argue that when we correlate age with gain after rendering Pintner score constant we are measuring the influence of age on ability to learn of men who are chosen as equally able to learn. The dispute would be partly about facts and partly about the nature of the problem to be solved. In respect of the facts it is not known to what extent the Pintner test, or any other so-called test of intelligence, is a measure or a symptom of the ability to learn the elementary school subjects, or to learn to add better, or to learn a code, or anything else.

A single Pintner test score is a very, very imperfect symptom of ability to learn these things in our adults, and certainly not a measure of it. As has been shown in Table 89, the correlations of the Pintner score with the learning composite measure for the first period varied from − .13 to + .21, averaging + .01. The two correlations of the Pintner score with the whole-period composite were + .19 and + .12. Those with the addition-practice gain averaged + .15. Those with the gain in rate of substitution averaged + .06. The correlation of the Pintner score with the gain in knowledge of the code was + .18. A short substitution learning is a part of the Pintner test itself.

As regards the problem to be solved, both questions are important. It is perhaps a doubtful choice whether we learn most by measuring the influence of age upon ability to learn in the case of adults of equal intelligence scores, or by measuring it in adults in general. We have consistently done the former. It

has seemed to us, and still seems, wiser to keep separate the changes which age makes in ability to learn and any changes which it may make in ability to score well in tests of intelligence. Then we are in a position to discover how far the former are paralleled, and perhaps constituted, by the latter.

From the point of view of the practice of adult education, it seems especially important to keep the two separate, since age and intelligence differ so greatly in their physiological, psychological, economic, and social accompaniments, and in the ways and means by which they are determined.

We do not know with surety whether the older prisoners are duller than the younger ones because men in general at 42 are duller than men in general at 22, or because the selection of this prison school favored greater dullness in the old. But the latter is probably the chief factor.[1] In so far as the latter is the fact, it would not be justifiable to use the total correlation as a measure of the relation in adults in general. In the case of the prisoners, the correlations are so low that the answer will be much the same to the first problem as to the second, by any reasonable allotment of potency to mere age and to the school's selection.

The slight extent to which our final result has been affected by partialling out intelligence and initial test scores is shown by the fact that the mid-value of the total coefficients (age with gain) differs from the mid-value of the second order partials by only .02. Also, $r_{12 \cdot 4}$ is on the average only .03 more negative than $r_{12 \cdot 34}$. In the partials obtained with attitude, $r_{12 \cdot 45}$ is only .01 more negative than $r_{12 \cdot 345}$ ($-$ .14 to $-$ .13). For the 42 American-born men originally in Standards III and IV, the correlation between age and intelligence is $-$ .01 and between age and initial score .00. For this group, for which it is not necessary to partial out either intelligence or initial score, the correlation between age and school learning for the whole period is $-$ .07.

[1] The facts concerning the influence of age on ability to score well in intelligence tests is presented in Chapter XII on Age and Qualitative Difference in Learning.

Concrete Estimates of the Decline in Ability to Learn

For the group, mentioned above, of 42 American-born men originally in Standards III and IV, for whom r_{13} is $-.01$ and r_{14} is .00, the regression line of $r_{12.34}$ is the same as that for r_{12}, which can be directly computed from the original data. By this regression line the gain at age 41 will be $\frac{5.1}{5.7}$ or 89 per cent of the gain at age 21. Our empirical determination of these per cents for all the experiments on prisoners (in Chapter V) was 90. This 90 corresponds roughly to the r_{12} of $-.10$, obtained for these persons. $r_{12.345}$ is $-.13$, and $r_{12.45}$ is $-.14$, but these are probably a little low because of the confusion of attitude with ability. The r_{12} which would probably be obtained from a group of low intellectual level alike in Pintner score, initial score, and in attitude perfectly measured, may be set as about $-.12$. The per cent for the gain of age 41 on the gain of age 21 in such a group may then be set as about 89.

If the drop in Pintner score is treated as an inevitable feature of age and a part of learning ability, the per cent for a low-level group alike in initial score and in attitude perfectly measured but falling off with age in the Pintner score as these men did, may be set as 87 or 88.

By any reasonable treatment of the facts, the drop from age 21 to 41 is small, probably between 6 and 14 per cent. At what age it begins and what is its exact course, we cannot determine from the data of these experiments.

APPENDIX VIII

The Relation of Retention and Transfer to Age in Adult Prisoners

Retention

The relation between age and retention in the substitution experiment is shown in Table 93. In rate of substitution the measure of retention is the extent to which the men took up their work after a week's interval without loss. It is not the rate after the interval, but that rate minus the first-day final rate. On the other hand, in measuring retention of knowledge of the code, we have used as a measure of retention the knowledge after the interval, not the difference between knowledge after and before. In both cases the correlation is low but positive between age and retention. It remains positive and is increased when intelligence and initial rate or knowledge are rendered constant.

This result with one presented earlier — that age and learning are negatively correlated — seems to contradict a statement generally accepted as true, that those who learn most remember most. An examination of the total coefficients will show, however, that there is no contradiction. There is a positive correlation of .23 between the first-day final rate and retention, and one of .73 between knowledge of code gained and knowledge of code retained. Furthermore the first of these coefficients would be much larger if corrected for the error described by Thorndike ('24) and by Thompson ('24).

TABLE 93

Retention of learning in the substitution experiment.

RATE OF SUBSTITUTION				
The measure of retention is the rate after an interval of one week minus the final rate on the first day				
	1. Age	2. Retention	3. Intelligence	4. 1st day Final
1. Age . . .		+.06	−.33	−.23
2. Retention . .	+.06		+.14	+.23
3. Intelligence .	−.33	+.14		+.55
4. 1st day Final .	−.23	+.23	+.55	
$N = 54$ $r_{12 \cdot 34} = +.13 \pm .09$				

KNOWLEDGE OF CODE				
The measure of retention is the knowledge of the code after the interval of one week				
	1. Age	2. Retention	3. Intelligence	4. 1st day Final Knowledge
1. Age . . .		+.05	−.26	−.07
2. Retention . .	+.05		+.32	+.73
3. Intelligence .	−.26	+.32		+.18
4. Knowledge at end of 1st day	−.07	+.73	+.18	
$N = 59$ $r_{12 \cdot 34} = +.23 \pm .08$				

TABLE 94

Transfer of learning in the substitution experiment.

IN REVERSE SUBSTITUTION

The measure of transfer is the rate in reverse substitution minus the rate before the reversal. The transfer for the group was only slightly negative.

	1. Age	2. Transfer	3. Intelligence	4. 1st day Final
1. Age . . .		+.01	−.33	−.18
2. Transfer . .	+.01		−.08	−.41
3. Intelligence .	−.33	−.08		+.52
4. 1st day Final .	−.18	−.41	+.52	

$N = 54$
$r_{12 \cdot 34} = -.02 \pm .09$

IN THE USE OF A NEW CODE

The measure of transfer is the rate of using the new code minus the retained rate of using the first code. Transfer for the group was decidedly negative.

	1. Age	2. Transfer	3. Intelligence	4. Retained Rate	5. Retained Knowledge
1. Age . . .		−.03	−.33	−.18	+.05
2. Transfer . .	−.03		−.20	−.76	−.64
3. Intelligence .	−.33	−.20		+.52	+.32
4. Retained Rate	−.18	−.76	+.52		+.61
5. Retained Knowledge .	+.05	−.64	+.32	+.61	

$N = 54$
$r_{12 \cdot 34} = -.17 \pm .09$
$r_{12 \cdot 345} = -.10 \pm .09$

Transfer

The first of the two studies of transfer, the one in reverse substitution, was planned to show the relation between age and transfer in a situation where the acquired skill would be more an advantage than a disadvantage. The second study was planned to show the same relation where the skill gained would hinder more than it would help. The results of the second part were as expected, the correlation between retained knowledge and transfer being − .64; but the first study did not show a positive transfer. The correlation between retained knowledge and transfer was − .14. This coefficient is too low to make it worth while to partial out retained knowledge as we did in the second part. There, with the transfer decidedly negative for the group, the correlation was − .10 between age and transfer with intelligence, retained rate and retained knowledge rendered constant. When exactly the same work was done after a week's interval, the older men started off more nearly at their maximum rate; when the work was changed in such a way as to be slightly confusing, the older men were at a very, very slight disadvantage; and when the change of work was quite confusing the older men began it with a greater loss. The coefficients are not very significant in view of their large probable errors, but since the reliability of the measures involved is high, they at least suggest that the more negative the transfer the more the older men lose by the change.

APPENDIX IX

Estimating the Gains of Various Evening High School Groups in Terms of the Tests' Scores

In Table 5 of Chapter VI, we arrived at certain weighted average differences in gain expressed as divergences from the median gain for the study in question in units of the variability (median deviation) of the gain for the study in question. Using 14 to mean the 14–16-year group, 17 to mean the 17–19-year group, and so on, these were:

17−14 . . .	.33	25−20 . . .	−.23
20−14 . . .	.49	30−14 . . .	.33
20−17 . . .	.15	30−17 . . .	.07
25−14 . . .	.38	30−20 . . .	−.15
25−17 . . .	.02	30−25 . . .	.01

We wish to compute a reasonable placement of 14, 17, 20, 25, and 30 to fit these differences. The difference between the two extremes, 20 and 14, is .49 when taken direct; it is .48 when taken *via* 17 by adding .15 and .33; it is .61 when taken *via* 25 by adding .23 and .38; it is .48 when taken *via* 30 by adding .15 and .33. On the average, it is .515. We shall use .52 for it. The difference between 20 and 17 is .15, .25, or .22, according as we take it direct or *via* 25 or *via* 30. The average for it is .21. The difference between 17 and 14 is .33 taken direct, and .31 by .52 −.21. We shall use .20 and .32 as the probable differences between 17 and 20 and 17 and 14. The difference between 20 and 30 is .15 taken direct. The difference between 14 and 30 is .33 if taken direct, .40 if taken *via* 17, and .39 if taken *via* 25; the average of the three determinations is .37. We, therefore, use .15 and .37 as the differences of the 30 group from 20 and 14 respectively. The difference between 25 and 20 is .23 if taken direct and .16 if taken *via* 30 (averaging .19½). The difference between 25 and 14 is .38, .35, or .32 (averaging .35), according as we take it direct, or *via* 17, or *via* 30. The

difference between 25 and 30 taken direct is .01. We use .17 and .35 as the differences of 25 from 20 and 14, which puts 25 at a difference of .02 below 30. We have then, using the 17 group as a point of reference:

$$\begin{aligned} 14 &= K - .32 \\ 17 &= K \\ 25 &= K + .03 \\ 30 &= K + .05 \\ 20 &= K + .20 \end{aligned}$$

The closeness of fit of the differences between these placements and the observed differences is sufficient for our purposes.

We wish next to estimate from these differences the gains for generalized age groups freed from the peculiarities of school, color, or language difficulty. We compute the actual gain for the group of age 17 to 19. This is our largest group and is a not greatly different fraction of the *N* whites, the *N* colored, the *E* not handicapped, and the *E* handicapped. (56 out of 134, or 42 per cent; 59 out of 133, or 44 per cent; 98 out of 184, or 53 per cent; 13 out of 49, or 27 per cent.) The weighted average for group 17 is + .06. So we use .06 for *K*, and have:

$$\begin{aligned} 14 &= -.26 \\ 17 &= .06 \\ 25 &= .09 \\ 30 &= .11 \\ 20 &= .26 \end{aligned}$$

If we assume that the differences in gain between age groups are the same for any one subject as for any other, we may interpret these gains in terms of the test scores as shown in Table 95. The estimated gain for age 30 or over by these determinations is about 86 per cent of the gain from 20 to 24.

If we use in the same way the differences in gain after making allowance for the differences in *CAVD* score, attendance, and reported home study, we start with:

17 − 14	.32	25 − 20	− .15
20 − 14	.42	30 − 14	.27
20 − 17	.10	30 − 17	.03
25 − 14	.41	30 − 20	− .18
25 − 17	.08	30 − 25	− .06

The difference between the two extremes, 20 and 14, is .42 when taken direct; it is .42 when taken *via* 17 by adding .10 and

TABLE 95

Estimated gains of evening high-school pupils in terms of units of the tests' scores.

	MEDIANS			VARIABILITIES			ESTIMATED GAINS					GAINS EXPRESSED AS PER CENTS OF COLUMN 9 THE GAIN FOR 20–24			
	1	2	3	4	5	6	7	8	9	10	11				
	Obtained, School *E*	Obtained, School *N*	Used in computing Columns 7 to 11	Obtained, School *E*	Obtained, School *N*	Used in computing Columns 7 to 11	Age 14–16	Age 17–19	Age 20–24	Age 25–29	Age 30 or over	Per cent 7 is of 9	Per cent 8 is of 9	Per cent 10 is of 9	Per cent 11 is of 9
Algebra . .	1.6	2.1	1.9	2.1	2.3	2.2	1.3	2.0	2.5	2.1	2.1	52	80	84	84
Biology . .	8.6	11.0	9.8	6.0	7.0	6.5	18.1	10.2	11.5	10.4	10.5	70	89	90	91
Civics . . .	2.0	3.0	2.5	10.0	7.0	8.5	.4	3.0	4.6	3.3	3.4	9	65	72	74
English . .	3.0	4.0	3.5	7.0	7.0	7.0	1.7	3.9	5.3	4.1	4.3	32	74	77	81
French . . .	5.0	5.0	5.0	5.5	6.0	5.8	3.5	5.4	6.5	5.5	5.6	54	83	85	86
German . .	8.0	6.0	7.0	10.0	4.0	7.0	5.2	7.4	8.8	7.6	7.8	59	84	86	89
Latin . . .	8.5	16.3	12.4	12.0	11.0	11.5	9.4	13.1	15.4	13.5	13.6	61	85	88	88
Spanish . .	5.0	20.0	12.5	7.0	11.0	9.0	10.2	13.0	14.8	13.3	13.5	69	88	90	91
											Average	51	81	84	85¼
											Median	56½	83½	85½	87

.32; it is .56 when taken *via* 25 by adding .15 and .41; it is .45 when taken *via* 30 by adding .18 and .27. On the average it is .46+. We use .46 for it. The difference between 20 and 17 is .10, .23, or .21, according as we take it direct or *via* 25 or *via* 30. The average is .18. The difference between 17 and 14 is .32 taken direct, and .28 by .46 − .18. The average is .30. We shall use .17 and .29 as the probable differences between 17 and 20 and 17 and 14. The difference between 14 and 30 is .27 if taken direct, .35 if taken *via* 17, and .35 if taken *via* 25. The average of these three determinations is .32. We use .16 and .30 as probable differences of the 30 group from 20 and 14 respectively. The difference between 25 and 14 is .41, .40, or .33 (averaging .38), according as we take it direct or *via* 17 or *via* 30. The difference between 25 and 20 taken direct is .15. We use .24 and .12 as the differences of 25 from 20 and 14, which puts 25 at a difference of .04 above 30.

We have then, using the 17 group as a point of reference:

$$\begin{aligned} 14 &= K - .29 \\ 17 &= K \\ 30 &= K + .01 \\ 25 &= K + .05 \\ 20 &= K + .17 \end{aligned}$$

These make about as close a fit to the observed corrected differences as is attainable.

Putting .06 for K, we have:

$$\begin{aligned} 14 &= -.23 \\ 17 &= \ .06 \\ 30 &= \ .07 \\ 25 &= \ .11 \\ 20 &= \ .23 \end{aligned}$$

Transforming into terms of units of the tests' scores we have the entries of Table 96.

TABLE 96

Estimated gains of evening high-school pupils in terms of the tests' scores, after allowance for differences in *CAVD* score, attendance, and reported home study. The medians and variabilities used are the same as in Table 95.

	GAINS					GAINS EXPRESSED AS PER CENTS OF COLUMN 9, THE GAIN FOR 20–24			
	7	8	9	10	11				
	Age 14–16	Age 17–19	Age 20–24	Age 25–29	Age 30 or over	14–16	17–19	25–29	30 or over
Algebra	1.4	2.0	2.4	2.1	2.1	58	83	88	88
Biology	8.3	10.2	11.3	10.5	10.3	72	90	93	91
Civics	.5	3.0	4.5	3.4	3.1	11	67	75	69
English	1.9	3.9	5.1	4.3	4.0	37	76	84	78
French	3.7	5.4	6.3	5.6	5.4	59	86	89	86
German	5.0	7.4	9.0	7.8	7.5	56	82	87	83
Latin	9.8	13.1	15.0	13.6	13.2	65	87	91	88
Spanish	10.4	13.0	14.6	13.5	13.1	71	89	92	90
Average						54	83	87	84
Median						58½	84½	88½	87

APPENDIX X

Detailed Facts Concerning Learning in Secretarial Schools

Typing

As stated in Chapter VII, we have the following measures for each individual:

1. age at the time of the first test
2. intelligence, the score in *Army Alpha*
3. ability in typing in the first test, number of lines minus 0.1 times number of errors.
4. reported number of hours spent on typing up to the first test
5. ability in typing in the last test, number of lines minus .1 (number of errors)
6. reported number of hours spent on typing between the first test and the last
7. total reported hours spent on typing, (4 plus 6)
8. gain in typing, (score 5 minus score 3)
9. ability to write shorthand symbols for words and phrases in the first test — the number correct out of 150 in a modified Hoke test
10. reported number of hours spent on shorthand up to the first test
11. ability to write shorthand symbols for words and phrases in the last test, the number correct out of 150 in a modified Hoke test
12. reported number of hours spent on shorthand between the first test and the last
13. total reported hours spent on shorthand, (10 + 12).
14. gain in shorthand, (score 11 minus score 9)
15. number of symbols written per 100 seconds in the first shorthand test

16. number of symbols written per 100 seconds in the last shorthand test
17. gain in rate, (16 minus 15)

The averages for the age groups **15 to 16, 17 to 19,** 20 to 24, 25 to 29, and 30 **and over** are presented in Table 97. Table

TABLE 97

The learning of typewriting in seven classes in secretarial schools by individuals of ages 15 to 16, 17 to 19, 20 to 24, 25 to 29, and 30 or over.

		15 to 16	17 to 19	20 to 24	25 to 29	30 or over	15 to 16 − 17 to 19	20 to 24 − 17 to 19	25 to 29 − 17 to 19	30 or over − 17 to 19
Class *C*		N = 2	N = 22	N = 14		N = 1				
2	Alpha	148	139	142		167	−9	3		28
3	Typing score, first	49.0	41.4	43.6		33.0	7.6	2.2		−8.1
4	Hours to first	34.0	50.5	34.6		20.0	−16.5	−15.9		−30.5
5	Typing score, last	154.5	129.1	125.9		93.0	25.4	−3.2		−36.1
6	Hours, first to last	262.0	212.6	201.3		182.0	49.4	−11.3		−30.6
7	Total hours	196.0	263.1	235.9		202.0	32.9	−27.2		61.1
8	Gain, first to last	105.5	87.7	82.3		60.0	17.8	−5.4		−27.7
Class *G. C.*			N = 9	N = 23	N = 6	N = 1				
2	Alpha		151	155	130	117		4	−21	−34
3	Typing score, first		54.1	51.8	37.2	118.0		−2.3	−16.9	63.9
4	Hours to first		50.2	51.6	35.2	84.0		1.4	−15.0	33.8
5	Typing score, last		162.2	160.3	132.0	196.0		−1.9	−30.2	27.8
6	Hours, first to last		205.2	223.5	247.2	220.0		18.3	42.0	14.8
7	Total hours		255.4	275.1	282.2	304.0		19.7	26.8	48.6
8	Gain, first to last		108.1	108.5	94.8	78.0		0.4	−13.3	−30.1
Class *G. N. C.*			N = 53	N = 20						
2	Alpha		143	149				6		
3	Typewriting, first		58.5	56.9				−1.6		
4	Hours to first		45.9	48.9				3.0		
5	Typing score, last		162.8	158.7				−3.1		
6	Hours, first to last		247.8	231.2				−16.6		
7	Total hours		293.7	280.1				−13.6		
8	Gain, first to last		104.3	101.8				−2.5		
Class *U. S.*			N = 19	N = 5	N = 1					
2	Alpha		140	155	164			15	24	
3	Typing score, first		73.7	59.2	27.0			−14.5	−46.7	
4	Hours to first		77.3	40.4	25.0			−36.9	−52.3	
5	Typing score, last		111.6	87.6	64.0			−24.0	−47.6	
6	Hours, first to last		40.6	35.6	40.0			−5.0	−0.6	
7	Total hours		117.9	76.0	65.0			−41.9	−52.9	
8	Gain, first to last		37.9	28.4	37.0			−9.5	−0.9	

TABLE 97 — *Continued*

The learning of typewriting in seven classes in secretarial schools by individuals of ages 15 to 16, 17 to 19, 20 to 24, 25 to 29, and 30 or over.

		15 to 16	17 to 19	20 to 24	25 to 29	30 or over	15 to 16 − 17 to 19	20 to 24 − 17 to 19	25 to 29 − 17 to 19	30 or over − 17 to 19
Class *M*		N = 13	N = 12	N = 5		N = 1				
2	Alpha	107	127	116		75	−20	−11		−52
3	Typing score, first	55.4	67.3	65.4		45.0	−11.9	−1.9		−22.3
4	Hours to first	61.2	74.9	101.6		52.0	−13.7	26.7		−22.9
5	Typing score, last	99.2	121.4	95.8		74.0	−22.2	−25.6		−47.4
6	Hours, first to last	79.9	106.5	101.0		20.0	−26.6	−5.5		−83.5
7	Total hours	141.1	181.4	202.6		72.0	−40.3	21.2		−109.4
8	Gain, first to last	43.8	54.1	30.4		29.0	−10.3	−23.7		−25.1
Class *P*		N = 10	N = 12	N = 1						
2	Alpha	114	122	159			−8	37		
3	Typing score, first	74.3	75.6	46.0			−1.3	−29.6		
4	Hours to first	69.7	99.8	30.0			−30.1	−69.8		
5	Typing score, last	107.2	99.8	73.0			7.4	−26.8		
6	Hours, first to last	65.7	53.1	34.0			12.6	−19.1		
7	Total hours	135.4	152.9	64.0			−17.5	−88.9		
8	Gain, first to last	32.9	24.2	27.0			8.7	2.8		
Class *G*			N = 46	N = 28	N = 5	N = 1				
2	Alpha		138	146	163	178		8	25	40
3	Typing score, first		159.9	145.0	135.0	132.0		−14.9	−24.9	−27.9
4	Hours to first		187.3	138.6	124.6	105.0		−48.7	−62.7	−82.3
5	Typing score, last		170.2	161.7	163.2	153.0		−8.5	−7.0	−17.2
6	Hours, first to last		29.9	29.8	21.0	21.0		−0.1	−8.9	−8.9
7	Total hours		217.2	168.4	145.6	126.0		−48.8	−71.6	−91.2
8	Gain, first to last		10.3	16.7	28.2	21.0		6.4	17.9	10.7

97 also reports the differences between the averages for ages 17 to 19 and each of the later age groups, in each of the seven classes.

Our prime concern in the case of typing is with measures 8 and 6 (the gain in typing score from our first test to our last test, and the hours of study during this interval). No. 8 is a measure whose meaning is unambiguous, and No. 6 (the time devoted to learning to typewrite between our first and our last test) was reported carefully, and so far as we know, accurately. Our next most important measures are 3 and 4, (the gain in typing from an assumed initial score of approximately zero, and the

reported number of hours spent in attaining it). There may have been certain individuals who began their class work with certain positive degrees of ability, and the reports of 4, being from casual memory rather than a deliberate record, are not so reliable as those of 6. Such errors will do no harm for our purposes unless there is an age difference in the way of overestimate or underestimate. This seems unlikely.

The intelligence measures are useful as a check upon the substantial equivalence in mental level of our age groups, that is, as indications that the older groups in any class are such as the younger group in that class will become.

The differences between the age groups are combined for all seven classes in Table 98, weights being given in proportion to

TABLE 98

The learning of typewriting: weighted average differences between the group aged 17 to 19 and each of the other age groups.

		15 to 16 — 17 to 19	20 to 24 — 17 to 19	25 to 29 — 17 to 19	30 or Over — 17 to 19
2	Alpha	− 13.0	+ 5.8	+ 1.9	− 4.5
3	Typing score, first	− 5.5	− 6.7	− 22.7	+ 1.4
4	Hours to first	− 18.0	− 19.9	− 38.0	− 25.5
5	Typing score, last	− 5.5	− 5.4	− 22.0	− 16.7
6	Hours, first to last	− 3.9	− 5.5	− 17.2	− 27.8
7	Total hours	− 21.9	− 25.4	− 55.2	− 53.3
8	Gain, first to last	0	+ 1.3	+ .7	− 18.1
	Total number of the smaller populations of the groups compared	24	82	12	4

the smaller of the two populations in each case. It seems desirable also to combine them with some weighting according to the amount of time reported as spent in learning. This involves two weightings, one according to 4 (the time reported as spent up to the first test) and the other according to 6 (the time reported as spent between the first and last tests).

As they stand in Table 98, the differences between the age groups in 3 and 8 are already weighted in a rough proportion to 4

and 6 respectively (the amount of time spent), since any age difference that exists in ability to learn will in the long run be a larger gross amount (the larger the period of learning) and since gross amounts were combined in computing the facts of Table 98. Table 98 may thus be taken to represent approximately what would have been found if those of any one age group in all seven classes had had the same amount of reported time for study. The differences between different age groups in time of study are, of course, a quite different matter, and are to be allowed for in the interpretation of Table 98.

As it stands, Table 98 shows that in our most reliable measure, the gain in score from the first to the last test, there are no demonstrable age differences. The 15 to 16 group, the 20 to 24 group, and the 25 to 29 group do a little better than the 17 to 19 group, gaining as much or more with less study time reported. The group aged 30 or over gain much less and also report much less study. In the gain made (assuming that all began near zero) up to the first test, those younger and older than the 17 to 19 group, gain on the average considerably less, but also reported considerably less time spent. In the gain in score for the entire learning, reckoned from zero to the last test, there were inferiorities to the 17 to 19 group of 5.5, 5.4, 22.0, and 16.7 but these may be due to the smaller amounts of practice reported — respectively 21.9, 25.4, 55.2, and 53.3. Roughly these figures mean 4, 4, 16, and 12 per cent inferiority in gain and 10, 12, 25, and 24 per cent less time of study.

The facts of Table 98 can be made to tell a clearer story, if allowances are made for differences in intelligence as measured by *Alpha* and for differences in the amount of time of study reported.

We first inquire whether there is any difference between those of high and those of low intelligence score (in the same typing class) in respect of the amount of time devoted to the study of typing up to the first test or from the first to the last test. We compute the average (and also the median) number of hours of study reported by the higher and lower half[1] of each class in intelligence score. The results appear in Table 99.

[1] Sometimes a few cases near the median in intelligence score are counted in neither half.

TABLE 99

Differences between those scoring high and those scoring low in intelligence in amount of time of practice reported. The times in the first line for each group are averages; those in the second are medians.

CLASS	GROUP	N_l	N_h	2 AVERAGE ALPHA SCORE		4 TIME TO FIRST TEST		6 TIME FROM FIRST TO LAST TEST		EXCESS IN ALPHA	EXCESS TIME REPORTED BY HIGH ALPHAS	
				l	h	l	h	l	h		In 4	In 6
C. . .	17–19	8	8	127	160	40	67	214	217	33	27	3
						38	38	226	207			
G. C. .	20–24	11	12	136	172	49	54	218	228	36	5	10
						18	18	221	233			
G. N. C.	17–19	25	24	129	160	52	42	231	261	31	−10	30
						22	22	223	246			
G. N. C.	20–24	9	8	129	160	49	21	219	235	34	−28	16
						22	22	220	241			
G. . .	17–19	21	22	129	163	183	192	30	32	38	9	2
						147	147	22	21			
G. . .	20–24	13	13	119	157	252	273	19	21	35	21	2
						127	127	21	21			
Weighted average (weights are, in order, 1, 1, 2, 1, 2, 1)											+3	+12

In obtaining the average difference, weights are given to the six determinations in the proportions: 1, 1, 2, 1, 2, 1. On the whole, the more intelligent half report slightly greater amounts of study (about 6 per cent).

We next inquire what the difference is in gain in typewriting score between those of high and those of low intelligence scores in the same class. The results appear in Table 100. A difference of 35 *Alpha* points corresponds to a difference in gain of about 2½ per cent. This is little, if any, more than might be accounted for by the slightly greater amount of reported study. We, therefore, need make no correction for the differences in *Alpha* score which characterize the age groups,[1] except possibly to bestow a very slight bonus on the 15–16 group.

We may estimate the allowance to be made for differences in reported time spent in two ways: First, we may make a general computation of the gains per hour of time reported at various

[1] − 13, + 6, + 2, and − 4½ *Alpha* points for groups 15 to 16, 20 to 24, 25 to 29, and 30 or over in comparison with group 17 to 19.

TABLE 100

Differences between those scoring high and those scoring low in intelligence in amount of gain in typing score.

CLASS	GROUP	DIFFERENCE IN ALPHA	CORRESPONDING SCORE IN FIRST TEST	DIFFERENCE IN GAIN, FIRST TO LAST TEST
C	17–19	33	4	− 9
G. C.	20–24	36	− 5	8
G. N. C.	17–19	31	5	4
G. N. C.	20–24	34	− 11	10
G.	17–19	38	6	4
G.	20–24	35	− 1	− 4
Weighted average		35	1	3

early and late stages of the learning, such as correspond roughly to the stages at which our experimental groups were located. Second, we may compare the gains of those reporting long times with the gains of those of the same age taught in the same class who report short times.

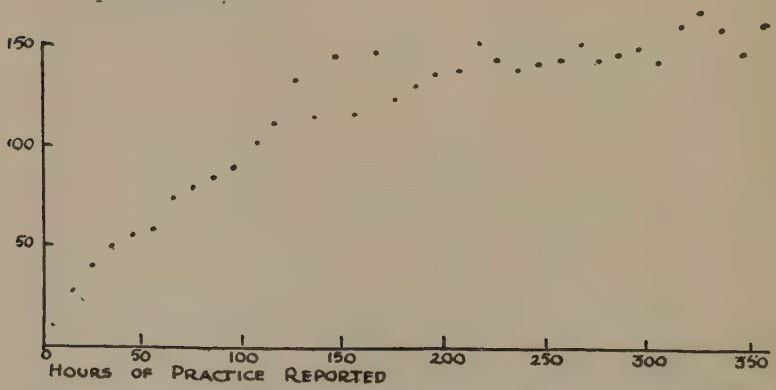


FIG. 24. MEDIAN SCORES IN TYPEWRITING AFTER VARIOUS AMOUNTS OF PRACTICE. (AFTER LITTLE ['27]).

In method I, we may use the results obtained by Little ('27) who has plotted the median typing scores in all tests for all

groups in relation to reported hours of study. The medians found by her (up to 350 hours) appear in Figure 24. By this method, the gain per hour of study may be estimated roughly as

1.0	from 40 to 80	.3	from 160 to 200
.6	" 80 to 120	.2	" 200 to 240
.4	" 120 to 160	.2	" 240 to 280

The facts for estimating the allowance by method II, are given in Tables 101 and 102.

TABLE 101

The gains in typing score, first test to last test of those reporting short and those reporting long amounts of study between the first test and the last.

Class	Group	Average Hours Reported up to Test 1	Populations of the Two Fractions of the Group Reporting Little (*L*) and More (*M*) than Average Amounts of Study		Average Number of Hours Reported, First Test to Last Test, by *L* and *M*		Average Gains in Typing Score, First Test to Last Test		Excess of *M* Over *L* in Hours Reported	Excess of *M* Over *L* in Gain	Excess in Gain per Extra Hour
			L	*M*	*L*	*M*	*L*	*M*			
C. . .	17–19	51	9	10	195	245	84	87	50	3	.06
C. . .	20–24	35	7	6	189	229	80	86	40	6	.15
G. C. .	17–19	50	4	4	185	225	117	110	40	−7	−.17
G. C. .	20–24	52	12	11	200	249	104	113	49	9	.18
G. N. C.	17–19	46	26	27	211	282	109	104	71	−5	−.07
G. N. C.	20–24	49	11	9	212	255	95	110	43	15	.35
U. S. .	17–19	77	9	10	25	53	42	35	28	−7	−.25
M. . .	15–16	61	7	6	52	113	45	43	61	−2	−.03
M. . .	17–19	75	6	6	68	145	50	57	77	7	.09
P. . .	15–16	70	5	5	38	94	39	27	56	−12	−.21
P. . .	17–19	100	6	6	38	68	28	21	30	−7	−.23
G. . .	17–19	187	27	18	19	42	15	7	23	−8	−.35
G. . .	20–24	139	4	24	14	21	11	18	7	7	1.00

6 groups show greater gains with longer times, 7 show smaller. If weights of 2, 1, 1, 2, 3, 2, 2, 1, 1, 1, 1, 2, and 1 are given to the groups (in the above order) the average increase in gain per added hour of reported study is .02.

TABLE 102

The typing score in the first test of those reporting short and those reporting long amounts of study up to the first test.

CLASS	GROUP	POPULATIONS OF THE TWO FRACTIONS OF THE GROUP REPORTING LITTLE AND (MUCH STUDY *L* AND *M*)		AVERAGE NUMBER OF HOURS REPORTED UP TO FIRST TEST, BY *L* AND *M*		AVERAGE TYPING SCORE IN TEST 1		EXCESS OF *M* OVER *L* IN HOURS REPORTED	EXCESS OF *M* OVER *L* IN GAIN	EXCESS IN GAIN PER EXTRA HOUR
		L	*M*	*L*	*M*	*L*	*M*			
C. . .	17–19	9	10	23	83	26	58	60	32	.53
C. . .	20–24	7	7	19	51	33	54	32	21	.66
G. C. .	17–19	4	4	15	71	24	77	56	53	.95
G. C. .	20–24	12	11	15	91	28	78	76	50	.67
G. N. C.	17–19	See Note 1								
G. N. C.	20–24	See Note 2								
U. S. .	17–19	9	10	30	124	47	101	94	54	.58
M. . .	15–16	7	6	24	106	43	69	82	26	.32
M. . .	17–19	6	6	45	105	57	78	60	21	.35
P. . .	15–16	5	5	35	104	66	82	69	16	.23
P. . .	17–19	6	6	50	133	63	88	83	25	.30
G. . .	17–19	27	19	132	266	144	177	134	33	.25
G. . .	20–24	20	8	120	185	141	156	65	15	.23

NOTE 1. — 9 cases of time averaging 17 gained 23. 28 cases of 22 gained 44. 3 cases of 28 gained 45. 6 cases of 50 gained 102. 7 cases of 182 gained 112.

NOTE 2. — 5 cases of time averaging 20 gained 42. 12 cases of 22 gained 49. 3 cases of 135 gained 114.

In the case of the time spent from the first test to the last test, it makes very little difference to our final conclusions which method of estimate is employed. At times around 200 hours, the gain per hour is little, if any, over one fifth of a point of typewriting score. The gain as estimated by the second method is practically *nil*.

Our uncorrected results of Table 98, which show differences of the age groups (from the 17–19 group) will be altered only as shown in Table 103 by the extreme allowance.

All the differences of Table 103 save the last are small in proportion to the gains themselves and to their own errors of estimate. The last is small in proportion to its error of estimate.

TABLE 103

Gains in typing scores, first test to last test, in relation to age.

AGE GROUP	GAIN	
	Uncorrected, from Table 98	Corrected by allowance of ⅕ point per hour of reported study
15–16	0.0	+ 0.8
17–19	0.0	0.0
20–24	+ 1.3	+ 2.4
25–29	+ .7	+ 4.1
30 or over	− 18.1	− 12.5

It should be borne in mind that all the other groups are at an advantage over group 17 to 19 in the gain from first to last test because they had less practice up to the first test and so began at an earlier point on the parabolic curve. Two hundred hours of practice from 20 to 220 is worth more than two hundred from 30 to 230. Ages 25 to 29 and 30 or over have a special advantage in this respect, the records for item 4 (hours to first test) being (in comparison with group 17 to 19) − 18.0, 0.0, − 19.9, − 38.0, and − 25.5 for the age groups in order.

On the whole there is no demonstrable age difference in gain from the first to the last test. There is probably very little difference from 17 to near 30, and there is a drop thereafter.

In the case of the differences in the first-test score, the correction matters more because the age groups differ more in the average number of hours reported as the amount of study to the point, and because the influence of an added early hour of study is large. One hour from 40 to 80 corresponds to about one point of typewriting score by method I.

It is not, however, justifiable to correct for the differences in amount of time reported to the first test by a naïve application of method I.

Some, perhaps all, of the times which are more than twice the modal time reported include private practice before entering the school, using the sight method of typing and involving much irrelevant study and some practice in error. Such excess time is worth very little.

The facts to be used in method II are given in Table 102. The average allowance per hour of reported study, using weights of 2, 1, 1, 2, 3, 2, 2, 1, 1, 1, 1, 2, and 1, is .5. Applying this to the facts of Table 98 we have, for the scores in Test I, the facts of Table 104.

TABLE 104

Typing score in first test, in relation to age.

AGE GROUP	GAIN	
	Uncorrected, from Table 98	Corrected by allowing ½ point per hour of reported study
15–16	− 5.5	+ 3.5
17–19	0.0	0.0
20–24	− 6.7	+ 3.3
25–29	− 22.7	− 3.7
30 or over	+ 1.4	+ 14.2

There is no demonstrable effect of age upon the early learning.

As a check upon the results of Tables 103 and 104, we may apply an allowance of $\frac{1}{5}$ point per hour of total hours, to item 5 of Table 98 (final score). This gives the following inferiorities to group 17 to 19.

15–16	− 1.1
17–19	0.0
20–24	− 0.3
25–29	− 11.0
30 or over	− 6.0

On the whole there is no sure effect of age. The most probable estimate is zero influence from 17 to 25 and a slight drop in later ages, (about 5 per cent at age 30).

Shorthand

Our treatment of the facts for the ability to write shorthand symbols for words and phrases will follow the same lines as our treatment of typing score. Table 105 presents the facts for each class, and the differences between the 17 to 19 group and

Table 105

The learning of shorthand symbols in seven classes in secretarial schools by individuals of ages 15–16, 17–19, 20–24, 25–29, and 30 or over.

2 = Alpha. 9 = Shorthand—first. 10 = Hours to first. 11 = Shorthand—last. 12 = Hours—first to last. 13 = Total hours. 14 = Gain—first to last. 17 = Gain in rate—first to last.

	15 to 16	17 to 19	20 to 24	25 to 29	30 or Over	15 to 16 − 17 to 19	20 to 24 − 17 to 19	25 to 29 − 17 to 19	30 or Over − 17 to 19
Class *C*	N = 2	N = 22	N = 14		N = 1				
2	148	139	142		167	9	3		28
9	22.0	16.3	15.6		8.0	5.7	− 0.7		− 8.3
10	74.0	85.9	76.9		40.0	− 11.9	− 9.0		−45.9
11	130.0	117.3	122.5		125.0	12.7	5.2		7.7
12	493.5	414.1	412.4		395.0	79.4	− 1.7		− 19.1
13	587.5	500.0	489.3		435.0	67.5	− 10.7		− 65.0
14	108.0	101.0	106.9		117.0	7.0	5.9		16.0
17	37.3	25.1	19.1		14.0	12.3	−6.0		− 11.1
Class *G. C.*		N = 9	N = 23	N = 6	N = 1				
2		151	155	130	117		4	−21	− 34
9		41.5	30.0	29.2	16.0		− 11.5	− 12.3	− 25.5
10		33.4	39.4	33.3	12.0		6.0	− 0.1	− 21.4
11		113.7	117.7	108.0	117.0		4.0	− 5.7	3.3
12		231.4	267.2	278.2	295.0		35.8	46.8	63.6
13		264.8	306.6	311.5	307.0		41.8	46.7	42.2
14		72.2	87.7	78.8	101.0		15.5	6.6	28.8
17		32.3	22.1	20.0	22.0		− 10.2	− 12.3	− 10.3
Class *G.N.C.*		N = 53	N = 20						
2		143	149				6		
9		50.4	48.6				− 1.8		
10		43.4	34.2				− 9.2		
11		114.6	115.6				1.0		
12		267.7	280.0				12.3		
13		311.1	314.2				3.1		
14		64.2	67.0				2.8		
17		29.4	26.1				− 3.3		

TABLE 105 — *Continued*

The learning of shorthand symbols in seven classes in secretarial schools by individuals of ages 15–16, 17–19, 20–24, 25–29, and 30 or over.

2 = Alpha. 9 = Shorthand—first. 10 = Hours to first. 11 = Shorthand—last. 12 = Hours—first to last. 13 = Total hours. 14 = Gain—first to last. 17 = Gain in rate—first to last.

	15 TO 16	17 TO 19	20 TO 24	25 TO 29	30 OR OVER	15 TO 16 — 17 TO 19	20 TO 24 — 17 TO 19	25 TO 29 — 17 TO 19	30 OR OVER — 17 TO 19
Class *U. S.*		N = 19	N = 5	N = 1					
2		140	155	164			15	24	
9		52.9	50.2	21.0			− 2.7	− 31.9	
10		54.9	57.2	25.0			2.3	− 29.9	
11		79.2	76.8	90.0			− 2.4	10.8	
12		37.7	35.0	66.0			− 2.7	28.3	
13		92.6	92.2	91.0			− 0.4	− 1.6	
14		26.3	26.6	69.0			0.3	42.7	
17		5.7	1.2	14.5			− 4.5	8.8	
Class *M*	N = 13	N = 12	N = 5		N = 1				
2	107	127	116		75	− 20	− 11		− 52
9	30.7	72.5	61.2		0	− 41.8	− 11.3		− 72.5
10	35.2	56.5	57.0		0	− 21.3	0.5		− 56.5
11	90.8	111.0	101.8		50.0	− 20.2	− 9.2		− 61.0
12	109.1	122.2	110.6		40.0	− 13.1	− 11.6		− 82.2
13	144.3	178.7	167.6		40.0	− 34.4	− 11.1		− 138.7
14	60.1	38.5	40.6		50.0	21.6	2.1		11.5
17	9.1	11.0	11.3		14.7	− 1.9	.3		3.7
Class *P*	N = 10	N = 12	N = 1						
2	114	122	159			− 8	37		
9	47.6	62.6	42.0			− 15.0	− 20.6		
10	84.9	130.7	39.0			− 45.8	− 91.7		
11	120.3	115.3	109.0			5.0	− 6.3		
12	127.2	113.0	15.0			14.2	− 98.0		
13	212.1	243.7	54.0			− 31.6	− 189.7		
14	72.7	52.7	67.0			20.0	14.3		
17	14.5	14.0	10.5			.5	− 3.5		
Class *G*		N = 46	N = 28	N = 5	N = 1				
2		138	146	163	178		8	17	32
9		111.3	100.3	119.0	87.0		− 11.0	7.7	− 24.3
10		130.2	125.8	105.8	110.0		− 4.4	− 24.4	− 20.2
11		116.0	103.6	120.4	108.0		− 12.4	4.4	− 8.0
12		48.7	29.8	22.2	5.0		− 18.9	− 26.5	− 43.7
13		178.9	155.6	128.0	115.0		− 23.3	− 50.9	− 63.9
14		4.7	3.3	1.4	21.0		− 1.4	− 3.4	16.3
17		7.4	10.0	5.5	− 3.0		2.6	− 2.0	− 11.3

TABLE 106

The learning of shorthand: weighted average differences between group 17 to 19 and each of the other groups.

		15 to 16 — 17 to 19	20 to 24 — 17 to 19	25 to 29 — 17 to 19	30 or Over — 17 to 19
2	Alpha	− 13.0	+ 5.8	+ 1.9	− 4.5
9	Shorthand—first	− 26.9	− 6.7	− 5.6	− 32.7
10	Hours to first	− 30.2	− 5.6	− 12.7	− 36.0
11	Shorthand—last	− 7.5	− 3.3	− 0.2	− 14.5
12	Hours — first to last	+ 7.7	+ 2.9	+ 14.7	− 20.4
13	Total hours	− 29.9	− 3.5	+ 2.0	− 56.4
14	Gain — first to last	+ 19.4	+ 3.4	+ 5.4	+ 18.2
17	Gain in rate				
		− 1.4	− 2.4	− 6.2	− 7.3
Total n of smaller populations of the groups compared.		24	82	12	4

TABLE 107

Differences between those scoring high and those scoring low in intelligence in amount of practice reported. The times in the first line for each group are averages; those in the second line are medians.

Class	Group	n_l	n_h	2 *Alpha* Score		4 Time to First Test		6 Time, First to Last Test		Excess of h Over l		
				l	h	l	h	l	h	*Alpha*	4	6
C.	17–19	8	8	127	160	66 48	116 59	426 447	408 433	50	− 18	32
G. C.	20–24	11	12	136	172	29 20	47 15	276 241	259 253	18	− 17	1
G. N. C.	17–19	25	24	129	160	44 22	46 22	268 275	253 255	2	− 15	− 13
G. N. C.	20–24	9	8	129	163	50 22	21 21	292 285	281 264	− 29	− 11	− 40
G.	17–19	21	22	119	157	143 100	122 97	45 44	51 56	− 21	6	− 15
G.	20–24	13	13	133	168	129 120	114 116	34 27	21 21	− 15	− 13	− 28
Weighted average										− 1	− 8	−11

each of the others. These differences are combined for all seven classes in Table 106, weights being given in proportion to the smaller of the two populations in each case.

Table 107 shows that those of higher intelligence scores, spent slightly less time (.31 hour), in total hours per *Alpha*

TABLE 108

Differences between those scoring high and those scoring low in intelligence tests in gain in shorthand-score.

CLASS	GROUP	2 *Alpha* SCORE				9 SCORE IN FIRST TEST		14 GAIN, FIRST TO LAST TEST		SUPERIORITY OF *h* IN			
		l	*h*	*l*	*h*	*l*	*h*	*l*	*h*	*Alpha*	First test	Gain first to last	Last test
C. . .	17–19	8	8	127	160	14	23	106	101	33	9	−5	4
G.C. .	20–24	11	12	136	172	26	34	84	91	36	8	7	15
G. N. C.	17–19	25	24	129	160	41	61	63	63	31	20	0	20
G. N. C.	20–24	9	8	129	163	55	43	66	64	31	−12	−2	−14
G. . .	17–19	21	22	119	157	107	115	6	4	34	8	−2	6
G. . .	20–24	13	13	133	168	93	108	6	1	38	15	−5	10
Weighted average										35	10	−1	8

point. Table 108 shows that those of higher intelligence scores gained somewhat more than those of lower, almost one fourth (.23) of a shorthand-score point per *Alpha* point.

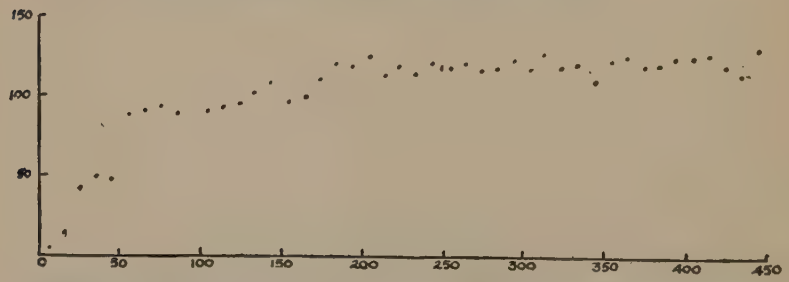


FIG. 25. MEDIAN SCORES IN KNOWLEDGE OF SHORTHAND SYMBOLS AFTER VARIOUS AMOUNTS OF PRACTICE. (AFTER LITTLE ['27])

Figure 25, taken from Little ('27), shows the general relation of shorthand-score to reported hours of study. Table 109 shows the differences in gains from the first test to the last test of those reporting much time and those reporting little time spent in study in the interval from the first test to the last. With the aid of these facts we may infer what the facts of Table 106 would be for age groups alike in *Alpha* score and time spent in study. We shall limit ourselves to the facts for "shorthand last" which utilizes all the data most fully.

TABLE 109

The differences in gain in shorthand between those reporting much and those reporting little study between the first and the last test.

CLASS	GROUP	POPULATIONS OF THE FRACTIONS OF THE GROUP REPORTING LITTLE STUDY (*L*) AND MUCH STUDY (*M*)		AVERAGE REPORTED HOURS OF STUDY BETWEEN FIRST AND LAST TEST		AVERAGE GAIN IN SHORTHAND-SCORE FROM FIRST TO LAST TEST		EXCESS IN HOURS OF STUDY *M* OVER *L*	EXCESS IN GAIN *M* OVER *L*	EXCESS IN GAIN PER HOUR OF EXCESS STUDY
		L	*M*	*L*	*M*	*L*	*M*			
C. . .	17–19	9	9	346	518	104	102	172	− 2	− .01
G. C. .	20–24	13	10	227	325	83	94	98	11	.11
G. N. C.	17–19	23	24	245	298	54	69	53	15	.28
G. N. C.	20–24	9	9	240	325	68	64	85	− 4	−.05
Weighted average										.12

In view of the fact that the greater gains for *Alpha* scores were made in spite of slightly less hours of study, we allow .25 of a point of gain per *Alpha* point. We allow .2 of a point of gain per hour of study. As a result we have the facts of Table 110.

The age groups are then substantially alike in gain, the extremes differing by only about 5 per cent. By any reasonable allowance for *Alpha* score and reported time this will still be true.

TABLE 110

Age differences in learning shorthand.

	SHORTHAND LAST	*Alpha*	TOTAL HOURS	ESTIMATED DIFFERENCES FROM 17–19 IN SHORTHAND-LAST FOR GROUP ALIKE IN *Alpha* AND IN TOTAL HOURS
15–16	− 7.5	− 13.0	− 29.9	+ 1.8
17–19	0.0	0.0	0.0	0.0
20–24	− 3.3	+ 5.8	− 3.5	− 4.0
25–29	− 0.2	+ 1.9	+ 2.0	− 1.1
30 or over . . .	− 14.5	− 4.5	− 56.4	− 2.3

If we use the same allowances with the gain from the first to the last test we have the facts of Table 111.

TABLE 111

Age differences in learning shorthand: differences from 17–19.

AGE GROUP	SHORTHAND, FIRST TO LAST	*Alpha*	HOURS, FIRST TO LAST	ESTIMATED DIFFERENCE FROM 17–19, FOR GROUPS ALIKE IN *Alpha* AND IN HOURS, FIRST TO LAST
15–16	19.4	− 13.0	7.7	21.1
17–19	0.0	0.0	0.0	0.0
20–24	3.4	5.8	1.9	1.6
25–29	5.4	1.9	14.7	2.0
30 or over	18.2	− 4.5	− 20.4	23.3

APPENDIX XI

Details Concerning the Experiment in Connecting Numbers with Nonsense Syllables

Learning Syllable-Number Associations

Three-digit numbers were written alongside the 100 three-letter nonsense[1] syllables given by Whipple ('10), p. 247. This list of syllable-number pairs was divided into two similar series of 50 each, as listed in Tables 112 and 113. Each pair was pasted in black letters and figures on 9 x 4 white cards. The letters and figures were about 1 inch high and ¾ inch wide. The pairs in Table 112 were called Form I and those in Table 113 were called Form II. Test sheets (page 288) were

Table 112

Fifty syllable-number combinations, called Form I

vel	148	yef	529
zen	183	rin	549
vem	136	orp	571
eit	162	ige	592
nis	187	gom	689
zud	176	ool	624
dro	269	euk	654
wol	214	sef	683
zig	247	ank	657
luh	268	jur	768
ild	287	rik	715
rud	263	nuc	734
elt	364	ipp	759
urf	317	ume	796
dri	348	fid	843
geb	367	nir	817
cha	386	zet	837
gah	359	orm	856
arb	487	ung	872
zan	423	geg	834
bli	457	tau	964
ite	476	ahn	916
rab	498	uff	936
ift	541	lin	953
aum	582	ruj	973

Table 113

Fifty syllable-number combinations, called Form II

tud	167	pud	532
ilt	127	buh	569
smi	158	spo	589
nen	173	tef	649
gla	194	lom	618
lud	243	arg	639
rad	289	ept	672
lel	238	ibe	697
pum	251	ong	742
heb	274	pof	783
arl	293	vid	726
omb	347	dak	746
irm	382	eig	764
ruv	328	teg	749
euf	352	ech	861
gur	379	tob	821
bri	394	pha	847
pru	462	urs	863
baw	419	urp	947
ret	431	kun	981
ime	461	zib	926
ull	482	gos	948
zin	467	orl	968
acq	563	ith	984
jek	513	tas	942

[1] RIN appearing twice in Whipple's list was in one case changed to NIR and likewise a PRU was changed to URP.

prepared, listing the syllables with blank spaces in which the subject might record the numbers learned. The syllables were thoroughly shuffled from their order in Tables 112 and 113 before being listed on the test blanks, to eliminate the sequence of numbers in the tables.

The subjects were women, summer-school students at the North Carolina College for women, Greensboro, N. C. They were the students in the following classes: General Psychology, Educational Psychology, Psychology of Individual Differences, Psychology of Elementary School Subjects, Psychology of Learning, and Educational Measurements.

The experiment was conducted during the second half of the class period, Table 112 being used on a Friday, and Table 113 on the following Monday. Only 25 cards were used because of the limited time available.

The following instructions were read by Dr. Tilton on Friday, after passing test sheets previously numbered in serial order.

Test Sheet

N. C. C. W. Learning Test
Form I

dri	.....	ift	.....
ung	.....	elt	.....
sef	.....	rin	.....
jur	.....	orm	.....
cha	.....	aum	.....
orp	.....	ruj	.....
luh	.....	bli	.....
ipp	.....	geg	.....
zet	.....	arb	.....
ild	.....	geb	.....
rik	.....	zen	.....
nuc	.....	rab	.....
gah	.....	nis	.....
gom	.....	ahn	.....
ige	.....	lin	.....
dro	.....	fid	.....
ume	.....	yef	.....
rud	.....	nir	.....
wol	.....	ite	.....
tau	.....	zud	.....
zig	.....	uff	.....
euk	.....	ank	.....
eit	.....	vel	.....
urf	.....	zan	.....
ool	.....	vem	.....

Test Sheet

N. C. C. W. Learning Test
Form II

euf	.....	acq	.....
urp	.....	irm	.....
ibe	.....	buh	.....
pof	.....	urs	.....
bri	.....	jek	.....
spo	.....	tas	.....
heb	.....	ime	.....
eig	.....	kun	.....
pha	.....	baw	.....
arl	.....	gur	.....
vid	.....	ilt	.....
dak	.....	zin	.....
pru	.....	gla	.....
lom	.....	gos	.....
tef	.....	ith	.....
rad	.....	ech	.....
teg	.....	pud	.....
omb	.....	tob	.....
lel	.....	ull	.....
zib	.....	lud	.....
pum	.....	orl	.....
ept	.....	ong	.....
nen	.....	tud	.....
ruv	.....	ret	.....
arg	.....	smi	.....

INSTRUCTIONS

Write your name at the top of the paper. Copy the number at the top of the paper in your book, for results will be reported by numbers instead of names. This is not a test of you, but an experiment in the Psychology of Learning. Here are 25 cards like these (show 2 sample cards). I'm going to show them to you 18 times. Then I'll ask you to write from memory as many of the numbers as you can, alongside the syllables in the first column. Write whatever number you think of, whether you're sure of it or not. We will not use the second column at all. This is the way it will go (show 2 sample cards, and on board show how subjects are to record the numbers learned). Now fold your paper lengthwise with the syllables inside and put it away till you're ready to use it.

Do your best, but don't be discouraged because your learning is slow. That is to be expected. Can you all see the sample card? (Adjust position of subjects and of cards for best light and maximum comfort.) All right.

The experiment was carried on with these three groups of subjects by the same experimenter, with careful attention to uniformity of conditions. The cards were held on a pile of books upon the desk during exposure. Each card was exposed for 2 seconds. After an interval of 10 seconds, during which the cards were shuffled, the process was repeated until the cards had been exposed 18 times. The subjects, already provided with the test paper, then recorded their learning.

On Monday the following instructions were given:

Pass papers; announce: do not write your name, just write the number I gave you on Friday, unless you were absent, or have forgotten it, in which case write your name. Don't think because we're repeating this test that your work was unsatisfactory. On the contrary, I was very well pleased with the results for a first trial, but the results to-day will be more dependable. You know just how it goes; now make yourself comfortable and do your best. This is another series of 25 cards similar to the series I used Friday. I will show them 18 times, just as I did Friday; and then you will write as many numbers as you can remember, on the dotted lines of column one. We will have no use for column two. In recording the numbers, it is best to go right down the column rapidly writing whatever number seems to be right, but not stopping long when you can't think of a number. Then when you get

to the bottom go back and go through the list again. Now fold your paper lengthwise with the type inside and put it away till you're ready to use it. Can you see the sample cards the way I am holding them? All right, we will begin.

After Form II was completed the following announcement was made.

Now write your age on your last birthday, at the top of your paper. You need not feel sensitive about putting your correct age down; for your name will not appear on my records. I shall use your number, not your name. I asked you to write your name on Friday's paper only as a safeguard in case you forgot your number. I want your correct age because I'm studying the relation between age and learning capacity and I am very anxious for my conclusions to be dependable.

The papers were scored by assigning two points for each number wholly correct and one point for three correct digits incorrectly placed and one point for two correct digits in the correct position.

The number of women from whom two scores were obtained is 150. Their ages and total scores are:

	Average	S. D.	Range
Age	27.8 yr.	10.4 yr.	18–54
Score	19.8	10.7	3–62

The reliability coefficient for an individual's score, as predicted by the Spearman-Brown formula, using the Friday and Monday records, is .80.

APPENDIX XII

Data on Drawing Lines: Main Experiment

The facts concerning the drawing, with eyes closed, of lines to be 3, 4, 5, and 6 inches in the set of 600 before the training and the set of 600 after the training, are presented in Tables 114, 115, 116, and 117. The departures in excess of 150 are

TABLE 114

Learning to draw 3-inch lines with eyes closed: tests before and after the drawing of 1050 lines.

INDIVIDUAL	NUMBER OF RESPONSES		DIVERGENCE OF THE MEDIAN RESPONSE FROM THE CORRECT RESPONSE			VARIABILITY (Q) AROUND THE INDIVIDUAL'S OWN MEDIAN			AVERAGE DEVIATION FROM THE CORRECT RESPONSE		
	Before	After	Before	After	Improvement	Before	After	Change	Before	After	Change
Young											
16	143	146	−.94	+.31	.63	.20	.28	+.08	.98	.41	−.57
17	147	147	+.12	+.34	−.22	.25	.24	−.01	.28	.32	+.04
18	148	147	−.80	−.03	.77	.22	.23	+.01	.87	.27	−.60
19	147	154	−.46	+.27	.19	.38	.23	−.15	.59	.33	−.26
20	152	147	−2.30	+.30	2.00	.29	.27	−.02	1.29	.38	−.91
21	150	146	−.01	+.42	−.41	.34	.24	−.10	.38	.42	+.04
23	149	150	−.45	+.31	.14	.34	.35	−.01	.64	.44	−.20
25	149	151	−1.12	+.01	1.11	.34	.16	−.18	1.11	.22	−.89
26	150	150	−.46	+.31	.15	.32	.26	−.06	.80	.36	−.44
27	150	150	−.25	+.30	−.05	.39	.25	−.14	.54	.35	−.19
28	150	150	−.93	−.48	.45	.27	.31	+.04	.79	.58	−.21
29	148	150	+.46	+.07	.39	.47	.12	−.35	.62	.18	−.48
Old											
33	148	150	−1.59	+.24	1.35	.12	.18	+.06	2.12	.27	−1.85
34	150	147	−.79	+.02	.77	.23	.19	−.04	.84	.27	−.57
35	147	150	−.45	−.47	−.02	.43	.23	−.20	.63	.56	−.07
36	150	150	−.87	−.32	.55	.19	.25	+.06	.94	.45	−.49
37	150	150	−.23	+.41	−.18	.34	.27	−.07	.36	.43	+.07
40	150	147	+.11	.00	.11	.42	.26	−.16	.50	.32	−.18
41	150	150	−.05	−.27	−.22	.30	−.48	+.18	.37	.54	+.17
42	147	148	+.43	+.82	−.39	.33	.28	−.05	.58	.76	+.18
43	151	150	−1.02	−.39	.63	.23	.30	+.07	1.04	.48	−.56
44	148	146	+.66	−.08	.58	.51	.20	−.31	.76	.24	−.52
46	146	150	−.03	−.34	−.31	.25	.31	+.06	.33	.46	+.13
48	149	153	+.64	+.83	−.19	.43	.25	−.18	.75	.80	+.05

due to the individual's failing to keep in accord with the signals and drawing extra lines. The departures below 150 are due to omissions or to two lines being so superimposed that the scorer could not measure the length with surety. The facts concerning the number of "right" responses in each of the nine sets of 600 are presented in Table 118. The identification numbers for the individuals are the same as those used for them in the experiments in "wrong-hand" writing and learning *Esperanto*. The arrangement is in the order of age. All entries except for the number of responses are in inches as units.

TABLE 115

Learning to draw 4-inch lines.

INDIVIDUAL	NUMBER OF RESPONSES		DIVERGENCE OF THE MEDIAN RESPONSE FROM THE CORRECT RESPONSE			VARIABILITY (Q) AROUND THE INDIVIDUAL'S OWN MEDIAN			AVERAGE DEVIATION FROM THE CORRECT RESPONSE		
	Before	After	Before	After	Improvement	Before	After	Change	Before	After	Change
Young											
16	150	149	−1.41	+.38	1.03	.27	.29	+.02	1.43	.47	−.96
17	150	150	−.24	+.58	−.34	.32	.31	−.01	.44	.59	+.15
18	151	150	−1.16	+.06	1.10	.37	.29	−.08	1.25	.36	−.89
19	146	150	−.91	+.14	.77	.60	.21	−.39	.96	.29	−.67
20	150	150	−1.95	+.01	1.94	.35	.33	−.02	1.90	.38	−1.52
21	150	150	−.56	+.12	.44	.34	.23	−.11	.66	.29	−.37
23	150	150	−.50	+.58	−.08	.45	.38	−.07	.76	.65	−.11
25	148	156	−1.45	−.20	1.25	.32	.22	−.10	1.50	.33	−1.17
26	148	150	−.60	+.26	.34	.46	.26	−.20	.68	.35	−.33
27	150	150	−.83	+.12	.71	.55	.20	−.35	.91	.30	−.61
28	150	150	−.69	−.99	−.30	.40	.34	−.06	.79	1.03	+.24
29	148	150	+.45	+.03	.42	.46	.16	−.30	.71	.22	−.49
Old											
33	150	150	−2.30	+.10	2.20	.19	.32	+.13	2.10	.23	−1.87
34	149	150	−.84	+.21	.63	.33	.28	−.05	.87	.34	−.53
35	148	149	−.78	−.66	.12	.74	.23	−.51	1.03	.80	−.23
36	150	150	−1.46	−.51	.95	.26	.34	+.08	1.51	.65	−.86
37	150	150	−.78	+.30	.48	.36	.31	−.05	.83	.42	−.41
40	149	150	+.18	−.03	.15	.45	.36	−.09	.57	.48	−.09
41	155	150	−.20	−.04	.16	.34	.42	+.08	.45	.48	+.03
42	148	148	+.41	+1.30	−.89	.32	.28	−.04	.56	1.22	+.66
43	150	150	−1.05	−.60	.45	.41	.39	−.02	1.12	.78	−.34
44	147	150	+.29	−.06	.23	.40	.39	−.01	.58	.45	−.13
46	146	155	−.33	−.93	−.60	.27	.29	+.02	.45	.93	+.48
48	146	149	+.30	+.69	−.39	.55	.30	−.25	.79	.70	−.09

TABLE 116

Learning to draw 5-inch lines.

INDIVIDUAL	NUMBER OF RESPONSES		DIVERGENCE OF THE MEDIAN RESPONSE FROM THE CORRECT RESPONSE			VARIABILITY (Q) AROUND THE INDIVIDUAL'S OWN MEDIAN			AVERAGE DEVIATION FROM THE CORRECT RESPONSE		
	Before	After	Before	After	Improvement	Before	After	Change	Before	After	Change
Young											
16	150	150	− 1.97	+ .43	1.54	.27	.31	+ .04	2.01	.53	− 1.48
17	149	150	− .51	+ .60	− .09	.38	.33	− .05	.69	.61	− .08
18	150	150	− 1.25	+ .41	.84	.32	.31	− .01	1.30	.49	− .81
19	149	150	− 1.01	+ .12	.89	.58	.28	− .30	1.13	.37	− .76
20	148	150	− 2.19	+ .31	1.88	.47	.44	− .03	2.22	.57	− 1.65
21	148	150	− .68	− .15	.53	.26	.19	− .07	.78	.29	− .49
23	150	150	− .45	+ 1.23	− .78	.46	.42	− .04	.73	1.13	+ .40
25	148	151	− 2.09	− .47	1.52	.41	.27	− .14	2.08	.64	− 1.44
26	150	150	− .47	+ .41	.06	.73	.42	− .31	.93	.54	− .39
27	150	150	− .77	+ .13	.64	.70	.31	− .39	.97	.39	− .58
28	150	150	− 1.01	− .75	.26	.47	.44	− .03	1.03	.89	− .14
29	151	150	+ .12	+ .03	.09	.42	.16	− .26	.65	.25	− .40
Old											
33	148	150	− 2.98	+ .26	2.72	.12	.34	+ .22	2.75	.34	− 2.41
34	150	150	− .84	+ .41	.43	.41	.43	− .02	.90	.57	− .33
35	146	149	− .81	− .90	− .09	.91	.43	− .48	1.26	.97	− .29
36	147	150	− 2.12	− .21	1.91	.19	.43	+ .24	2.02	.53	− 1.49
37	150	150	− 1.23	+ .66	.57	.38	.43	+ .05	1.50	.69	− .81
40	151	150	+ .32	+ .58	− .26	.54	.35	− .19	.64	.62	− .02
41	150	150	+ .19	+ .31	− .12	.39	.40	+ .01	.56	.51	− .05
42	148	150	+ .37	+ 1.76	− 1.39	.56	.56	.00	.71	1.65	+ .94
43	150	150	− .84	− .37	.47	.54	.36	− .18	1.15	.54	− .61
44	149	150	+ .15	+ .03	.12	.44	.35	− .09	.56	.37	− .19
46	145	150	− .63	− .94	− .31	.31	.46	+ .15	.73	.93	+ .20
48	138	150	+ .67	+ .84	− .17	.71	.43	− .28	1.01	.98	− .03

TABLE 117

Learning to draw 6-inch lines.

INDIVIDUAL	NUMBER OF RESPONSES		DIVERGENCE OF THE MEDIAN RESPONSE FROM THE CORRECT RESPONSE			VARIABILITY (Q) AROUND THE INDIVIDUAL'S OWN MEDIAN			AVERAGE DEVIATION FROM THE CORRECT RESPONSE		
	Before	After	Before	After	Improvement	Before	After	Change	Before	After	Change
Young											
16	148	149	−2.28	+1.14	1.14	.39	.36	−.03	2.32	1.14	−1.18
17	152	149	−.76	+.79	−.03	.58	.42	−.16	.84	.81	−.03
18	150	153	−1.36	+.42	.94	.30	.27	−.03	1.41	.47	−.94
19	149	150	−1.21	+.14	1.07	.67	.33	−.34	1.31	.38	−.93
20	149	153	−2.42	+.19	2.23	.75	.43	−.32	2.50	.52	−1.98
21	148	148	−.77	+.18	.59	.49	.29	−.20	.93	.34	−.59
23	150	150	−.22	+1.61	−1.39	.89	.44	−.45	.99	1.63	+.64
25	145	143	−2.61	−.53	2.08	.40	.28	−.12	2.62	.64	−1.98
26	150	150	−.70	+.20	.50	.65	.40	−.25	.84	.47	−.37
27	150	150	+.67	+.08	.59	.89	.50	−.39	1.11	.46	−.65
28	150	150	−1.13	−.90	.23	.44	.36	−.08	1.15	.94	−.21
29	150	150	+.36	+.06	.30	.57	.16	−.41	.66	.22	−.44
Old											
33	149	151	−3.67	+.31	3.36	.28	.38	+.10	3.36	.40	−2.96
34	152	150	−.93	+.94	−.01	.56	.51	−.05	1.01	.81	−.20
35	144	146	−1.09	−1.00	.00	1.14	.48	−.66	1.46	1.16	−.30
36	152	150	−2.52	−.25	2.27	.32	.52	+.20	2.79	.62	−2.17
37	150	150	−1.77	+.38	1.39	.45	.39	−.06	1.79	.54	−1.25
40	150	153	+.28	+.48	−.20	.61	.41	−.20	.76	.58	−.18
41	144	150	+.50	+.56	−.06	.60	.57	−.03	.71	.78	+.07
42	145	150	+.34	+2.01	−.67	.51	.50	−.01	.70	1.89	+1.19
43	149	150	−.92	−.06	.86	.62	.44	−.18	1.10	.72	−.38
44	151	149	+.04	−.17	−.13	.42	.42	.00	.55	.45	−.10
46	146	144	−.79	−1.43	−.64	.41	.43	+.02	.86	1.43	+.57
48	138	149	+.42	+.91	−.49	.76	.65	−.11	.91	1.06	+.15

TABLE 118

Learning to draw 3-, 4-, 5-, and 6-inch lines — per cent of "right" responses in early and late tests and during the training itself.

INDIVIDUAL	EARLY TEST	PER CENT "RIGHT" IN TRAINING PERIODS							LATE TEST
		1	2	3	4	5	6	7	
Young									
16	1	38	48	49	52	56	54	61	21
17	28	47	56	69	61	65	68	67	21
18	2	40	47	50	51	58	55	57	33
19	13	34	33	47	53	49	35	56	39
20	0	25	42	45	40	47	41	44	30
21	15	30	47	52	58	58	58	57	37
23	13	35	43	42	47	48	52	60	9
25	1	37	38	44	44	44	55	60	28
26	16	46	50	43	49	34	51	54	28
27	12	37	43	45	35	45	49	60	36
28	12	33	38	39	50	30	46	42	11
29	24	55	62	75	77	85	88	93	65
Old									
33	0	32	48	50	24	36	44	47	35
34	16	31	34	36	48	48	55	55	31
35	11	26	43	32	46	38	46	33	6
36	0	0	18	41	43	50	46	47	20
37	6	41	53	51	54	61	53	65	24
40	24	33	34	37	32	37	41	46	28
41	28	39	40	40	36	46	40	41	25
42	31	34	38	41	40	30	48	50	4
43	7	31	34	27	35	41	40	39	21
44	24	36	44	51	49	53	60	62	35
46	20	36	42	45	52	48	48	53	11
48	13	26	38	50	53	46	54	48	9

Improvement in drawing the lines may be considered as the result of a reduction in any tendency to draw too long or too short lines (so-called constant error) and of a reduction in the general spread or dispersion of the lengths (so-called variable error). The younger group improved more than the older in both respects. The reductions were as shown below.

In constant error, measured by the average difference of the median response from the true response:

	20–24	35 and Over
3 in.	from .70 to .27, a gain of .43	from .57 to .35, a gain of .22
4 in.	from .90 to .30, a gain of .60	from .74 to .29, a gain of .45
5 in.	from 1.04 to .42, a gain of .62	from .93 to .61, a gain of .32
6 in.	from 1.21 to .52, a gain of .69	from 1.20 to .63, a gain of .57

In variable error, measured by the average difference of the semi-interquartile range (Q) from the individual's own median:

	20–24	35 and Over
3 in.	from .32 to .25, a gain of .07	from .32 to .27, a gain of .05
4 in.	from .40 to .26, a gain of .14	from .39 to .33, a gain of .06
5 in.	from .46 to .33, a gain of .13	from .46 to .41, a gain of .05
6 in.	from .57 to .34, a gain of .23	from .56 to .48, a gain of .08

APPENDIX XIII

Data on Drawing Lines: Corroborative Experiments

Three adults, *Ru*, *T*, and *Wo*, 47, 51, and 47 years old, and six college undergraduates, *C*, *M*, *P*, *R*, *S*, and *Wa*, 17 to 21 years old, were given a chance to learn to draw lines 3, 4, 5, and 6 inches long at command with eyes bandaged.[1] When the individual drew a line within $\frac{1}{8}$ inch of the correct length for 3 inches, or within $\frac{1}{4}$ inch of the correct length for the other lengths, the teacher called out "Right." Otherwise he called out "Wrong."[2]

The gains from the test before training to the test after training are not strictly comparable for the three old and the six young. The old did not have the regular 600 series before the training, but only from 24 to 37 trials. The old had also had previous practice in drawing lines of some or all of the four lengths in question which may have reduced their prospects of gain by having already reduced their constant errors.

In the gains within the training series and the falling off from the last training period to the test without announcement of "Right" or "Wrong," the young and old are comparable.

The young and the old were about alike in the first 150, the average errors being .27, .34, .42, and .39 for the 3-inch, 4-inch, 5-inch, and 6-inch lines for the young, and .32, .34, .40, and .50 for the old. The young improved more than the old, their reductions in the average error being .14, .18, .24, and .19, whereas those of the old were .07, .04, .05, and .09. An estimate of the reliability of the differences may be obtained by using the total reduction of each individual. This sum was .55, .40, .61, .61, 1.09, and 1.08 for the six young individuals, averaging .72. For the three older it was .63, .35, and − .17,

[1] The method of the experiment was that described in Chapter IX.

[2] In the case of *T*, "right" was announced only for lines within $\frac{1}{8}$ in. for all lengths.

averaging .27.[1] The difference of .45 in favor of the younger is over two times its mean square error, and would have hardly one chance in a hundred of being obtained if the ages were really equal in ability to learn the ability in question.

At the end of the 1050 practices for each length a series of 600 trials, 150 for each length, was taken with no announcement of "Right" or "Wrong." Both groups fell off in precision when this guidance was removed, but the older group lost more — an average of .36 inches to .29 inches for the young group.

[1] Except that one of the old individuals had 1650 trials with each length.

APPENDIX XIV

Data of Dr. Calvin Stone on the Relation of Ability to Learn to Age in Animals

TABLE 119

Average time (in seconds) and errors for each of thirty successive trials in the multiple T maze, for rats of various ages. Data of Calvin Stone.

	GROUP I 25 DAYS N = 47		GROUP I *c* 50 DAYS N = 54		GROUP II 75 DAYS N = 25		GROUP II *c* 10 MONTHS N = 25		GROUP III 100 DAYS N = 21		GROUP III *c* 150 DAYS N = 16	
			Litter mates of Group I				Litter mates of Group II				Litter mates of Group III	
	Time	Errors	Time	Errors	Time	Errors	Time	Errors	Time	Errors	Time	Errors
1	169.2	7.5	169.3	6.5	254.9	8.2	178.8	5.6	316.3	8.2	275.1	7.1
2	101.8	6.6	82.6	6.3	253.7	8.3	124.7	6.8	281.9	6.9	170.5	6.8
3	63.7	4.8	47.0	5.1	205.8	7.3	80.6	6.2	122.2	7.1	122.0	6.7
4	51.1	3.9	40.7	4.5	99.2	6.4	94.5	6.6	101.5	6.5	166.6	7.4
5	37.8	3.3	24.4	3.4	93.6	6.4	57.9	5.7	76.7	6.8	147.3	6.8
6	25.0	2.8	21.6	2.9	83.0	4.8	63.9	5.7	63.2	5.7	60.7	6.1
7	24.3	2.6	16.2	2.3	76.0	5.3	57.6	5.8	50.1	4.7	60.3	5.3
8	41.2	2.6	18.5	2.3	46.8	3.9	49.0	5.0	41.5	4.9	58.7	4.9
9	20.7	2.0	17.2	1.7	41.2	3.5	55.0	4.5	49.9	4.4	45.1	3.7
10	21.2	1.9	15.4	1.8	49.2	4.6	37.0	4.5	34.9	4.0	47.2	4.2
11	15.5	1.4	13.0	1.3	76.8	4.1	49.0	4.3	47.7	4.5	50.1	3.6
12	22.7	1.5	15.4	1.1	29.6	3.2	25.0	3.3	42.8	4.5	36.3	3.7
13	14.8	1.6	12.4	1.1	30.4	2.6	30.0	3.6	41.0	3.6	39.9	3.8
14	27.9	1.5	22.1	1.3	28.2	3.0	25.2	3.4	44.4	3.9	39.1	4.1
15	15.7	1.0	13.6	0.9	28.6	2.6	22.3	2.9	54.2	4.1	37.0	3.1
16	23.0	1.1	19.5	0.7	27.2	2.6	12.6	1.3	56.3	3.9	36.3	3.3
17	19.0	1.2	17.5	1.0	33.5	2.8	20.2	3.2	40.9	3.9	30.4	2.4
18	14.0	1.0	16.3	1.2	20.3	1.8	20.6	2.4	38.0	3.7	23.6	2.4
19	19.9	1.0	16.8	1.0	26.3	2.6	16.0	2.4	38.4	3.4	24.1	2.4
20	22.9	1.2	16.5	1.0	22.0	1.9	15.1	2.5	31.2	3.6	23.5	2.2
21	20.2	1.0	20.5	1.4	26.7	2.4	12.7	1.8	25.2	2.8	18.3	2.1
22	14.4	0.9	19.2	1.4	20.1	1.7	17.1	2.2	30.9	3.3	25.3	2.0
23	14.4	0.8	15.4	1.0	30.6	3.3	16.1	1.9	33.9	3.7	20.3	2.1
24	26.0	0.9	15.4	0.8	23.3	2.0	14.5	1.7	30.8	2.9	20.3	2.2
25	36.3	1.0	14.3	0.9	23.0	2.0	10.8	1.3	18.6	2.1	17.8	1.3
26	29.1	1.1	10.9	0.7	30.0	2.0	12.2	1.5	24.6	2.8	15.4	1.6
27	32.8	1.0	12.8	0.8	30.0	2.6	19.8	2.0	28.9	2.5	20.8	1.9
28	20.9	1.0	14.8	0.8	29.3	1.8	13.4	1.8	25.2	2.2	17.1	1.5
29	23.3	0.7	20.5	1.0	20.0	1.7	11.7	1.6	17.7	1.7	19.1	1.9
30	24.5	0.8	10.7	0.7	21.0	1.7	16.0	1.7	15.2	2.0	20.1	1.8

TABLE 119 — *Continued*

Average time (in seconds) and errors for each of thirty successive trials in the multiple T maze, for rats of various ages. Data of Calvin Stone.

	GROUP IV 6 MONTHS N = 29		GROUP IV *c* 1 YEAR N = 25		GROUP V 1 YEAR N = 35		GROUP V *c* 1½ YEAR N = 25		GROUP VI 9 MONTHS N = 25		GROUP VI *c** 1½ YEARS N = 17	
			Litter mates of Group IV				Litter mates of Group V				Litter mates of Group VI	
	Time	Errors	Time	Errors	Time	Errors	Time	Errors	Time	Errors	Time	Errors
1	220.7	7.3	229.3	6.5	275.6	6.5	288.2	7.4	239.6	7.1	176.4	7.3
2	137.6	7.0	130.0	6.2	245.3	7.3	170.6	6.0	244.3	7.3	96.8	6.2
3	84.8	6.5	145.0	7.4	199.9	7.0	123.0	6.0	159.4	7.6	50.1	5.6
4	58.8	5.8	90.4	5.8	146.5	6.5	82.6	6.1	117.2	7.0	47.1	4.4
5	50.1	5.7	59.2	5.0	137.2	5.7	74.8	5.7	96.3	7.2	44.4	5.3
6	35.9	4.6	39.5	4.1	99.7	5.2	75.5	5.7	54.1	5.6	26.1	3.1
7	32.1	4.3	24.9	3.4	85.7	4.8	53.2	5.0	42.6	5.3	20.8	2.9
8	30.7	3.7	27.4	3.4	82.0	4.6	42.0	4.1	37.2	5.0	20.0	2.8
9	20.3	3.2	24.1	3.4	77.9	3.9	52.0	4.5	38.7	5.1	44.8	3.7
10	18.4	2.9	19.6	2.8	65.1	3.5	30.5	3.6	23.5	3.3	14.9	2.2
11	19.9	3.1	17.8	2.7	78.6	3.8	27.4	3.2	22.1	3.7	20.8	2.6
12	18.6	2.6	22.0	3.2	68.9	3.4	25.5	3.2	19.8	3.2	22.8	2.5
13	14.9	2.1	17.6	2.5	74.6	3.1	22.9	3.2	20.8	3.2	12.2	1.5
14	14.1	2.0	14.7	2.2	53.4	3.0	21.1	2.9	18.5	2.8	10.6	1.1
15	14.8	1.9	13.8	1.9	61.9	3.2	21.6	2.2	22.6	3.5	13.9	1.6
16	15.6	2.5	12.7	1.5	49.0	3.2	23.3	2.5	19.7	2.9	10.9	1.2
17	13.8	2.0	15.2	2.0	40.2	2.5	28.0	2.5	17.6	2.8	17.6	1.5
18	17.1	1.8	17.9	2.3	35.9	2.4	21.4	2.3	17.5	2.7	10.5	1.2
19	13.2	1.9	17.5	2.0	27.2	1.8	26.9	2.8	17.4	2.1	9.9	.9
20	13.8	1.7	14.4	1.7	35.8	2.3	18.6	2.1	14.5	1.5	9.4	.9
21	10.4	1.2	14.0	1.6	29.9	2.5	21.5	2.1	16.4	2.0	10.4	.8
22	12.8	1.7	12.6	1.2	39.3	2.8	24.1	2.4	14.7	1.7	7.5	.2
23	10.2	1.1	12.9	1.2	30.1	2.2	28.1	2.3	15.8	1.7	8.0	.6
24	8.4	.8	23.2	1.0	24.6	2.0	30.0	2.3	14.8	1.8	7.1	.4
25	13.6	1.3	12.2	.8	26.7	2.2	24.0	1.9	15.8	1.7	7.3	.4
26	9.6	.8	10.2	.7	22.5	1.8	30.4	2.5	12.4	1.3	8.8	.8
27	11.1	1.1	8.9	.7	22.3	1.9	21.6	1.8	12.9	1.6	7.9	.6
28	11.5	1.1	14.3	.8	22.3	2.0	16.1	1.6	12.3	1.6	8.5	.6
29	12.2	1.1	9.0	.8	19.3	1.7	94.4	1.5	12.7	1.3	11.8	.6
30	15.1	1.7	15.6	1.3	20.8	1.5	19.1	2.0	10.6	1.2	7.9	.3

* Group VI *c* was kept on a low diet to approximate the hunger status of Groups I and I *c*.

APPENDIX XV

Memory Losses of Young and Old

If we pair with each of the summer-session adults of Henderson a pupil of 14, 15, or 16 who made approximately the same score in Test I, the differences between the scores in I and in III are as shown in Table 120, column 4. If we do the same,

TABLE 120

Differences between scores in memory of passages immediately after the learning (I) and four weeks later (III), in the case of old and young who were approximately alike in score immediately after the learning.

ADULT STUDENTS IN SUMMER SESSION		PUPILS OF 14, 15, OR 16		PUPILS OF 12 AND 13		PUPILS OF 10 AND 11	
I	I–III	I	I–III	I	I–III	I	I–III
64	9 −	63 +	6				
62	6 −	63	0	61	1	61	0
58 +	2 +	59	8 −	58 +	5		
58	9 −	57 +	5	58 +	5 +		
57	10	56 +	3 +	57 +	9 +	57	− 2
56	7	56	15	56 +	2 +		
54	4 −	54 +	6 +	54	5		
51 +	11	52	13	52 +	10	52 +	4
51	6 −	51	2	51 +	0	51 +	1 +
51	9	50	3 −	51	8		
49	1 −	49 +	− 3	49	8		
49	14	48 +	10 +	48 +	−9	46 +	3 +
45	6	45	22 −	45	15 −	46	9 −
45	10 −	45	12	44 +	10 +	42	3
42	4 −	43	8	42 +	2	42	13 −
41	6 −	38 +	2	41	15 −	42	6 −
Average			7.4		5.7		4.1
Average for adults of equal scores in I .			7.1		7.0		8.1

using ages 12 and 13, the I–III differences are as shown in Table 120, column 6. For 10 and 11, the facts are in column 8 of the same table. Tables 120*A* and 120*B* present similar comparisons for graduate students and college students, and for college students and pupils in the first half of grade 9 (plus three from the last half of grade 10). The pupils of 13 and younger fall off less in score during the four weeks than the adults and adolescents. After 14 there is no demonstrable difference. The data used are all from Henderson ('03), pp. 88–93. Three different sets of paragraphs were used so that the scores of Table 120 are not comparable with those of Table 120*A*, and neither set of these is comparable with those of Table 120*B*.

TABLE 120 A

Graduate Students		College Students	
I	I–III	I	I–III
51 +	19	51	8 −
44	17	43	11
40	21 −	41	16
39 +	21 +	39	18
38	7 −	38	25
38	13 −	36	7 −
34	7	35	4 −
32	4 −	32	7 −
26 +	6 +	28	11
Average	12.8		11.9

TABLE 120 B

College Students		Pupils in Grade 9 *	
I	I–III	I	I–III
60	12	60	46
57	14 −	57	9
56 +	9 +	56	23 +
53	−2	53 +	16
49	8 −	47	9 −
48	19 −	48 +	4 +
46 +	9 +	47	10
45	8 −	45 +	10 +
45	13	44	8 −
42 +	16 +	41 +	16
40	30	39	10
38	9	38	3 −
37	16	38	13 −
34 +	25	34	10 +
34	10	36	8
30	6	30	13
Average	12.6		13.0

* Including 3 from grade 10.

APPENDIX XVI

Age Differences in the Ratio of Omissions to Omissions Plus Errors

The fundamental table including the results of all counts of errors and omissions is Table 121. By combining certain age groups this becomes Table 122. The per cents for age 14 to 17 and the changes from age 14 to 17, to age 30 to 34 and to age 40 or over, computed from Table 122 are presented in Table 123.

The weights used were according to the number of x and $-$ together in the smaller of the populations compared, while weights of 1, 2, 3, 4, 6, 8, and 10 were given respectively for smaller populations of 1 to 9, 10 to 19, 20 to 49, 50 to 99, 100 to 199, 200 to 499, and 500 and over.

From Table 123, we have as the difference between age 16 and age 32½, using unweighted medians:

in *C*, by Level I, 12.5; by Level II, 7.8; av. 10.2
in *A*, by Level I, 15.8; by Level II, − 5.4; av. 5.2
in *V*, by Level I, 21.5; by Level II, 11.0; av. 16.3

Using weighted medians, they are:

in *C*, by Level I, 9.2; by Level II, 7.4; av. 8.3
in *A*, by Level I, 15.8; by Level II, − 4.3; av. 5.8
in *V*, by Level I, 21.5; by Level II, 19.6; av. 20.6

The corresponding figures for the difference between age 16 and age 45, using unweighted medians, are:

in *C*, 10.2, 20.0; av. 15.1
in *A*, 14.4, 9.6; av. 12.0
in *V*, 16.3, 8.4; av. 12.4

Using weighted medians, they are:

in *C*, 10.2, 18.9; av. 14.6
in *A*, 9.6, 9.6; av. 9.6
in *V*, 16.3, 8.4; av. 12.4

The unreliability of any one of these averages (determined by making computations for groups 360–369, 380–389, 400–409, and 420 on the one hand and 370–379, 390–399, and 410–419 on the other) is very great, about 6; but the general drift of either set is fairly sure.

Table 123 indicates that the age-change from 32 to 45 is much slower than the change from 16 to 32. The change from 16 to 32 is 31.6 or 34.6, while that from 16 to 45 is only 39.5 or 36.5, with an average difference of 4.4. The changes from each age group to the succeeding age group are presented in Table 124. In Table 124, we divide the changes in group 390 to 399 from 30–34 to 40 and over equally between 30–34 to 35–39, and 35–39 to 40 or over.

The facts of Table 124 corroborate those of Table 123, in showing a general increase in the percentage of omissions with age and in showing the increase from age 16 to 32½ to be five times that from 32½ to 45.

TABLE 121

The number of wrong or omitted elements, the number of omitted elements and the per cent which the latter is of the former, for each age and intelligence group. Individuals of *CAVD* intelligence scores from 360 to 369.

AGE	SEX	LEVEL *J*									LEVEL *K*								
		C			*A*			*V*			*C*			*A*			*V*		
		x −	−	%	*x* −	−	%	*x* −	−	%	*x* −	−	%	*x* −	−	%	*x* −	−	%
14–15	*M*	53	15	28.3	56	19	33.9	62	7	11.3	108	23	21.3	108	44	40.7	104	22	21.2
	F	95	18	18.9	122	38	31.1	106	12	11.3	172	41	23.8	175	78	44.6	147	29	19.7
16–17	*M*	84	17	20.2	66	19	28.8	97	21	21.6	137	25	18.2	113	47	41.6	126	38	30.2
	F	80	20	25.0	110	34	30.9	100	14	14.0	148	24	16.2	147	62	42.2	130	20	15.4
18–19	*M*	92	17	18.5	60	18	30.0	79	9	11.4	144	48	33.3	108	58	53.7	94	16	17.0
	F	13	10	76.9	16	4	25.0	14	6	42.9	19	9	47.4	20	15	75.0	16	10	62.5
20–21	*M*	20	4	20.0	15	6	40.0	16	4	25.0	28	13	46.4	33	22	66.7	34	18	52.9
	F	4	1	25.0	9	7	77.7	3	0	00.0	7	4	57.1	10	9	90.0	2	0	00.0
22–23	*M*	7	4	59.1	10	5	50.0	12	8	66.7	24	11	45.8	18	9	50.0	15	5	33.3
	F	5	2	40.0	7	3	42.8	3	2	66.7	8	2	25.0	9	7	77.7	2	2	100.0
24	*M*	0	0		5	1	20.0	3	2	66.7	6	1	16.7	6	1	16.7	6	5	83.3
	F	10	10	100.0	10	10	100.0	2	0	00.0	7	1	14.3	5	2	40.0	2	0	00.0
25–29	*M*	26	16	61.5	16	9	56.3	12	7	58.3	29	11	37.9	25	18	72.0	20	12	60.0
	F																		
30–34	*M*	4	1	25.0	3	2	66.6	2	0	00.0	6	1	16.7	7	3	42.8	2	0	0
	F	9	4	44.4	11	4	36.3	14	10	71.4	13	7	53.8	12	3	25.0	9	6	66.7

TABLE 121 — *Continued*

Individuals of *CAVD* intelligence scores from 370 to 379.

AGE	SEX	LEVEL *K*									LEVEL *L*								
		C			*A*			*V*			*C*			*A*			*V*		
		x –	–	%	*x* –	–	%	*x* –	–	%	*x* –	–	%	*x* –	–	%	*x* –	–	%
13–15	*M*	39	0	0	34	3	8.8	35	8	22.9	52	2	3.8	51	30	58.8	54	10	18.5
	F	196	30	15.3	165	38	23.0	167	26	15.6	285	65	22.8	233	71	30.5	249	43	17.3
16–17	*M*	165	26	15.8	125	31	24.8	134	20	14.9	229	63	27.5	226	140	61.9	170	28	16.5
	F	139	24	17.3	148	49	33.1	109	15	13.8	202	40	19.8	181	92	50.8	159	18	11.3
18–19	*M*	166	44	26.5	110	29	26.4	157	25	15.9	239	72	30.1	222	125	56.3	188	28	14.9
	F	48	7	14.6	62	26	41.9	42	2	4.8	74	12	16.2	81	46	56.8	49	0	0
20–21	*M*	54	5	9.3	33	4	12.1	40	5	12.5	72	18	25.0	81	40	49.4	55	11	20.0
	F	21	5	23.8	21	5	23.8	15	2	13.3	32	6	18.8	20	0	0	23	1	4.3
22–23	*M*	28	10	35.7	19	11	57.9	13	8	61.5	30	16	53.3	20	0	0	22	9	40.9
	F																		
24	*M*	4	0	0	7	4	57.1	3	1	33.3	7	6	85.7	10	10	100.0	5	1	20.0
	F	8	5	62.5	8	5	62.5	2	0	0	6	3	50.0	7	4	57.1	3	0	0
25–29	*M*	35	1	2.9	31	18	58.1	20	5	25.0	42	13	31.0	43	32	74.4	20	6	30.0
	F	12	3	25.0	19	6	31.6	5	1	20.0	20	7	35.0	30	25	83.3	12	2	16.7
30–34	*M*	7	0	0	5	0	0	2	0	0	6	0	0	9	0	0	2	0	0
	F	4	3	75.0	10	10	100.0	2	0	0	8	0	0						
40 or >	*M*	12	3	25.0	10	4	40.0	4	2	50.0	9	9	100.0	10	10	100.0	4	0	0
	F																		

TABLE 121 — *Continued*

Individuals of *CAVD* intelligence scores from 380 to 389.

AGE	SEX	LEVEL *L*									LEVEL *M*								
		C			*A*			*V*			*C*			*A*			*V*		
		x –	–	%	*x* –	–	%	*x* –	–	%	*x* –	–	%	*x* –	–	%	*x* –	–	%
14–15	*M*	240	30	12.5	148	38	25.7	219	18	8.2	264	24	9.1	359	164	45.7	371	99	26.7
	F	387	53	13.6	112	35	31.2	224	26	11.6	301	42	14.0	348	178	51.1	355	61	17.1
16–17	*M*	254	57	22.4	119	37	31.1	196	38	19.4	309	55	17.8	362	198	54.7	361	81	22.4
	F	173	40	23.1	126	57	45.2	135	12	8.9	224	25	11.2	328	200	61.0	235	54	23.0
18–19	*M*	140	20	14.3	97	26	26.8	112	13	11.6	161	10	6.2	212	119	56.1	209	30	14.4
	F	28	4	14.3	15	12	80.0	22	1	4.5	47	16	34.0	64	53	82.8	55	11	20.0
20–21	*M*	34	11	32.3	25	9	36.0	19	0	0.0	40	12	30.0	57	32	56.1	44	16	36.4
	F	23	4	17.4	33	20	60.6	16	2	12.5	21	4	19.0	42	29	69.0	24	0	0.0
22–23	*M*	38	18	47.4	46	10	21.7	30	2	6.7	42	13	31.0	40	25	62.5	47	16	34.0
	F	16	10	62.5	11	10	90.9	11	10	90.9	13	7	53.4	15	15	100.0	7	3	42.9
24	*M*	8	0	0.0	8	8	100.0	5	0	0.0	8	1	12.5	10	1	10.0	2	0	0.0
	F	10	6	60.0	5	0	0.0	4	2	50.0	6	2	33.3	9	6	66.7	7	3	42.9
25–29	*M*	74	27	36.5	52	40	76.9	42	7	16.7	67	23	34.3	68	48	70.6	32	5	15.6
	F	9	0	0.0	20	20	100.0	3	0	0.0	17	0	0.0	24	17	70.8	17	7	41.2
30–34	*M*	15	6	40.0	22	16	72.7	5	2	40.0	22	8	36.4	27	23	85.2	12	4	33.3
	F																		

TABLE 121 — *Continued*

Individuals of *CAVD* intelligence scores from 390 to 399.

AGE	SEX	LEVEL *M*									LEVEL *N*								
		C			*A*			*V*			*C*			*A*			*V*		
		x −	−	%	*x* −	−	%	*x* −	−	%	*x* −	−	%	*x* −	−	%	*x* −	−	%
14–15	*M*	12	0	0.0	22	13	59.1	14	1	7.1	*N*	not	written						
	F	63	25	39.7	86	43	50.0	69	10	14.5	22	3	13.6	22	9	40.9	17	6	35.3
16–17	*M*	67	5	7.5	58	22	37.9	79	7	8.8	*N*	not	written						
	F	83	3	3.6	121	72	59.5	67	9	13.4	68	6	8.8	104	72	69.2	57	19	33.3
18–19	*M*	115	4	3.5	155	47	30.3	99	9	9.09	6	1	16.7	4	0	0.0	8	7	87.5
	F	27	2	7.4	61	38	62.3	33	6	18.2	15	0	0.0	30	29	96.7	15	5	33.3
20–21	*M*	37	1	2.7	46	17	37.0	24	4	16.7	4	0	0.0	6	1	16.7	2	0	0.0
	F	11	2	18.2	13	8	61.6	6	1	16.7	*N*	not	written						
22–23	*M*	65	7	10.8	92	42	45.7	73	9	16.7	26	5	19.2	31	6	19.3	22	4	18.2
	F	23	0	0.0	36	14	38.9	20	2	10.0	30	1	3.3	32	11	34.4	20	2	10.0
24	*M*	13	0	0.0	25	14	56.0	16	0	0.0	14	5	35.7	19	3	15.8	9	1	11.1
	F	2	1	50.0	10	7	70.0	4	0	0.0	*N*	not	written						
25–29	*M*	31	7	22.6	31	19	61.3	24	1	4.1	7	0	0.0	6	0	0.0	6	0	0.0
	F	17	4	23.5	23	9	39.1	8	0	0.0	15	0	0.0	25	2	8.0	12	0	0.0
30–34	*M*	26	3	11.6	32	18	56.3	17	0	0.0	14	0	0.0	9	0	0.0	9	0	0.0
	F	4	0	0.0	5	1	20.0	1	0	0.0	8	0	0.0	6	0	0.0	1	1	100.0
35–39	*M*	7	0	0.0	20	18	90.0	5	3	60.0	*N*	not	written						
	F	12	2	16.7	32	26	81.3	9	0	0.0	20	0	0.0	36	21	58.3	13	3	23.1
40 or >	*M*																		
	F	5	0	0.0	13	10	76.9	4	0	0.0	10	3	30.0	12	10	83.3	8	3	37.5

TABLE 121 — *Continued*

Individuals of *CAVD* intelligence scores from 400 to 409.

AGE	SEX	LEVEL *N*									LEVEL *O*								
		C			*A*			*V*			*C*			*A*			*V*		
		x −	−	%	*x* −	−	%	*x* −	−	%	*x* −	−	%	*x* −	−	%	*x* −	−	%
14–15	*M*	12	0	0.0	4	0	0.0	5	0	0.0	18	0	0.0	16	7	43.7	16	2	12.5
	F	11	2	18.2	11	2	18.2	13	4	30.8	12	6	50.0	12	2	16.6	15	6	40.0
16–17	*M*	170	15	8.8	172	48	27.9	123	4	3.3	235	30	12.7	225	86	38.2	259	25	9.6
	F	165	14	8.5	257	86	33.5	144	26	18.1	244	45	18.4	319	190	59.5	255	75	29.4
18–19	*M*	113	12	10.6	115	12	10.4	100	13	13.0	164	37	22.6	164	59	36.0	192	38	19.8
	F	34	3	8.9	54	22	40.7	20	3	15.0	53	12	22.6	59	35	59.3	56	18	32.1
20–21	*M*	47	6	12.8	44	3	6.8	29	7	24.1	51	18	35.3	75	29	38.7	70	10	14.3
	F	10	1	10.0	22	0	0.0	10	1	10.0	19	1	5.3	30	17	56.7	21	4	19.0
22–23	*M*	64	11	17.2	80	13	16.3	34	4	11.8	78	18	23.1	123	57	46.3	111	20	18.0
	F	14	0	0.0	14	3	21.4	8	2	25.0	21	4	19.0	24	8	33.3	15	1	6.7
24	*M*	23	3	13.0	37	2	5.4	31	6	19.4	35	5	14.3	37	5	13.5	52	10	19.2
	F	4	0	0.0	4	0	0.0	6	0	0.0	4	0	0.0	7	0	0.0	7	0	0.0
25–29	*M*	84	9	10.7	46	10	21.7	46	10	21.7	113	33	29.2	80	27	33.8	105	28	26.7
	F	67	10	14.9	69	23	33.3	53	17	32.1	84	25	29.8	111	60	54.1	90	38	42.2
30–34	*M*	28	2	7.1	36	10	27.8	23	10	43.5	58	26	44.8	49	24	49.0	53	24	45.3
	F	54	7	13.0	66	13	19.7	36	6	16.7	77	6	7.8	88	37	42.0	77	12	15.6
35–39	*M*	21	8	38.1	15	1	6.7	16	5	31.3	37	23	62.2	26	12	46.2	33	13	39.4
	F	15	0	0.0	28	3	10.7	12	1	8.3	21	0	0.0	28	7	25.0	21	5	23.9
40 or >	*M*	10	2	20.0	4	0	0.0	5	0	0.0	13	7	53.8	7	1	14.3	12	2	16.7
	F	49	3	6.1	52	10	19.2	43	12	27.9	78	16	20.5	82	29	35.4	80	32	40.0

TABLE 121 — *Continued*

Individuals of *CAVD* intelligence scores from 410 to 419.

AGE	SEX	LEVEL *O*									LEVEL *P*								
		C			*A*			*V*			*C*			*A*			*V*		
		x –	–	%	*x* –	–	%	*x* –	–	%	*x* –	–	%	*x* –	–	%	*x* –	–	%
14–15	*M*	42	0	0.0	53	19	35.9	58	0	0.0	94	18	19.2	56	36	64.4	75	9	12.0
	F	19	7	36.8	22	5	22.7	21	8	38.1	45	8	17.8	21	12	57.2	33	4	12.1
16–17	*M*	140	0	0.0	127	17	13.4	153	26	17.0	219	37	16.9	137	52	37.9	187	56	29.9
	F	27	0	0.0	34	17	50.0	24	6	25.0	42	11	26.2	36	31	86.2	29	7	24.1
18–19	*M*	50	0	0.0	58	12	20.7	58	3	5.2	73	14	19.2	59	34	57.7	62	6	9.7
	F	4	0	0.0	12	4	33.3	8	0	0.0	13	0	0.0	15	10	66.7	9	2	22.2
20–21	*M*	62	6	9.7	92	38	41.3	96	12	12.5	99	7	7.1	94	49	52.2	94	9	9.6
	F	35	6	17.3	41	17	41.5	28	5	17.9	42	5	11.9	38	26	68.5	38	9	23.7
22–23	*M*	98	9	9.2	117	37	31.6	162	32	19.8	171	25	14.6	127	59	46.5	182	36	19.8
	F	34	3	8.8	55	31	56.4	40	6	15.0	64	17	26.6	54	34	63.0	52	20	38.5
24	*M*	4	0	0.0	2	0	0.0	6	1	16.7	4	0	0.0	2	1	15.0	7	3	42.9
	F	13	0	0.0	8	2	25.0	15	5	33.3	19	1	5.3	7	0	0.0	25	9	36.0
25–29	*M*	50	8	16.0	48	4	8.3	70	11	15.7	89	18	20.2	46	22	47.9	98	14	14.3
	F	76	10	13.2	71	19	26.8	97	21	21.6	139	28	20.1	86	44	51.2	130	52	40.0
30–34	*M*	45	7	15.6	37	13	35.1	54	22	40.8	78	13	16.7	50	29	58.0	62	25	40.4
	F	101	11	10.9	156	65	41.6	148	53	35.8	217	62	28.6	143	88	61.5	191	84	44.0
35–39	*M*	30	7	23.3	30	13	43.3	46	12	26.1	62	21	33.9	55	39	71.0	46	12	26.1
	F	56	12	21.4	51	22	43.2	54	19	35.2	98	25	25.5	37	18	48.7	82	29	35.4
40 or >	*M*	42	3	7.1	42	6	14.3	46	17	37.0	73	42	57.5	49	28	57.2	59	21	35.6
	F	76	21	27.6	78	35	44.9	67	19	28.4	133	35	26.3	80	52	65.0	82	24	29.3

TABLE 121 — *Continued*

Individuals of *CAVD* intelligence scores from 420 to 429.

AGE	SEX	LEVEL P									LEVEL Q								
		C			*A*			*V*			*C*			*A*			*V*		
		x −	−	%	*x* −	−	%	*x* −	−	%	*x* −	−	%	*x* −	−	%	*x* −	−	%
14–15	*M*																		
	F																		
16–17	*M*	5	0	0.0	5	0	0.0	3	0	0.0	8	1	12.5	4	0	0.0	9	0	0.0
	F	6	0	0.0	1	0	0.0	11	0	0.0	11	1	9.1	9	8	88.9	17	0	0.0
18–19	*M*	12	0	0.0	9	2	22.2	13	0	0.0	20	4	25.0	8	0	0.0	17	4	23.5
	F																		
20–21	*M*	54	2	3.7	45	0	0.0	63	7	11.1	87	13	14.9	42	24	57.1	77	6	7.8
	F	20	1	5.0	3	3	100.0	10	1	10.0	26	2	7.7	13	7	53.8	23	5	21.7
22–23	*M*	65	1	1.5	54	27	50.0	88	11	12.5	103	4	3.9	63	27	42.9	119	19	16.0
	F	5	0	0.0	6	5	83.3	1	0	0.0	6	0	0.0	4	4	100.0	5	0	0.0
24	*M*	16	0	0.0	11	4	36.4	14	1	7.1	20	0	0.0	12	6	50.0	27	3	11.1
	F	9	0	0.0	1	0	0.0	7	0	0.0	11	1	9.1	6	1	16.7	12	1	8.3
25–29	*M*	67	6	9.0	28	11	39.3	71	12	16.9	88	16	18.2	42	20	47.6	90	15	16.7
	F	61	5	8.2	24	10	41.7	58	15	25.9	72	9	12.5	42	32	76.2	68	11	16.2
30–34	*M*	27	7	25.9	21	14	66.7	22	8	36.4	35	9	25.7	10	2	20.0	39	15	38.5
	F	73	6	8.2	35	18	51.4	48	9	18.8	78	17	21.9	47	30	63.9	82	29	35.4
35–39	*M*	43	11	25.8	19	8	42.1	22	2	9.1	42	5	11.9	18	8	44.4	36	5	13.9
	F	52	1	1.9	15	4	26.7	41	10	24.4	61	13	21.3	45	36	80.0	71	29	40.8
40 or >	*M*	54	13	24.1	33	24	72.7	20	6	30.0	70	23	32.9	24	7	29.3	47	8	16.0
	F	58	6	10.3	37	27	73.0	22	5	22.7	65	20	30.8	38	25	68.4	59	16	27.1

TABLE 122

The facts of Table 121, with combination of sex and age groups
Individuals of *CAVD* intelligence scores from 360 to 369.

	LEVEL *J*									LEVEL *K*								
	C			*A*			*V*			*C*			*A*			*V*		
	x –	–	%	*x* –	–	%	*x* –	–	%	*x* –	–	%	*x* –	–	%	*x* –	–	%
14–17	312	70	22.4	354	110	31.1	365	54	14.8	565	113	20.0	543	231	42.5	507	109	21.5
18–21	129	32	24.8	100	35	35.0	112	19	17.0	198	74	37.4	171	104	60.8	146	44	30.1
22–24	22	16	72.7	32	19	59.4	20	12	60.0	45	15	33.3	38	19	50.0	25	12	48.0
25–29	26	16	61.5	16	9	56.3	12	7	58.3	29	11	37.9	25	18	72.0	20	12	60.0
30–34	13	5	38.5	14	6	42.9	16	10	62.5	19	8	42.1	19	6	31.6	11	6	54.5

Individuals of *CAVD* intelligence scores from 370 to 379.

	LEVEL *K*									LEVEL *L*								
	C			*A*			*V*			*C*			*A*			*V*		
	x –	–	%	*x* –	–	%	*x* –	–	%	*x* –	–	%	*x* –	–	%	*x* –	–	%
14–17	539	80	14.8	472	121	25.6	445	69	15.5	768	170	22.1	691	333	48.2	632	99	15.7
18–21	289	61	21.1	226	64	28.3	254	34	13.4	417	108	25.9	404	211	52.2	315	40	12.7
22–24	40	15	37.5	34	20	58.8	18	9	50.0	13	9	69.2	17	14	82.4	8	1	12.5
25–29	47	4	8.5	50	24	48.0	25	6	24.0	62	20	32.3	73	57	78.1	32	8	25.0
30–34	11	3	27.3	15	10	66.7	4	0	0	14	0	0	9	0	0	2	0	0
40 or >	12	3	25.0	10	4	40.0	4	2	50.0	9	9	100.0	10	10	100.0	4	0	0

TABLE 122 — *Continued*

Individuals of *CAVD* intelligence scores from 380 to 389.

	LEVEL *L*									LEVEL *M*								
	C			*A*			*V*			*C*			*A*			*V*		
	$x-$	–	%	$x-$	–	%	$x-$	–	%	$x-$	–	%	$x-$	–	%	$x-$	–	%
14–17	1054	180	17.1	505	167	33.1	774	94	12.1	1098	146	14.2	1397	740	53.0	1322	295	22.3
18–21	225	39	17.3	170	67	39.4	169	16	9.5	269	42	15.6	375	233	62.1	332	57	17.2
22–24	72	34	47.2	70	28	40.0	50	14	28.0	69	23	33.3	74	47	63.5	63	22	34.9
25–29	83	27	32.5	72	62	86.1	45	7	15.6	84	23	27.4	92	65	34.9	49	12	24.5
30–34	15	6	40.0	22	16	72.7	5	2	40.0	22	8	36.4	27	23	85.2	12	4	33.3

Individuals of *CAVD* intelligence scores from 390 to 399.

	LEVEL *M*									LEVEL *N*								
	C			*A*			*V*			*C*			*A*			*V*		
	$x-$	–	%	$x-$	–	%	$x-$	–	%	$x-$	–	%	$x-$	–	%	$x-$	–	%
14–17	225	33	14.7	287	150	52.3	229	27	11.8	90	9	10.0	126	81	64.3	74	25	33.8
18–21	190	9	4.7	275	110	40.0	162	20	12.3	25	1	4.0	40	30	75.0	25	12	48.0
22–24	103	8	7.8	163	77	47.2	80	1	1.3	70	11	15.7	82	20	24.4	51	7	13.7
25–29	48	11	22.9	54	28	51.8	32	1	3.1	22	0	0	31	2	6.5	18	0	0
30–34	30	3	10.0	37	19	51.4	14	0	0	22	0	0	15	0	0	10	1	10.0
35–39	19	2	10.5	52	44	84.6	14	3	21.4	20	0	0	36	21	58.3	13	3	23.1
40 or >	5	0	0	13	10	76.9	4	0	0	10	3	30.0	12	10	83.3	8	3	37.5

TABLE 122 — *Continued*

Individuals of *CAVD* intelligence scores from 400 to 409.

	LEVEL *N*									LEVEL *O*								
	C			*A*			*V*			*C*			*A*			*V*		
	$x -$	–	%	$x -$	–	%	$x -$	–	%	$x -$	–	%	$x -$	–	%	$x -$	–	%
14–17	358	31	8.7	444	136	30.6	285	34	11.9	509	81	15.9	572	285	49.8	545	108	19.8
18–21	204	22	10.8	235	37	15.8	159	24	15.1	287	68	23.7	328	140	42.7	339	70	20.6
22–24	105	14	13.3	135	18	13.3	79	12	15.2	138	27	19.6	191	70	36.6	185	31	16.8
25–29	151	19	12.6	115	33	28.7	99	27	27.3	197	58	29.4	191	87	45.6	195	66	33.8
30–34	82	9	11.0	102	23	22.5	59	16	27.1	135	32	23.7	137	61	44.5	130	36	27.7
35–39	36	8	22.2	43	4	9.3	28	6	21.4	58	23	39.7	54	19	35.2	54	18	33.3
40 or >	59	5	8.5	56	10	17.9	48	12	25.0	91	23	25.3	89	30	33.7	92	34	37.0

Individuals of *CAVD* intelligence scores from 410 to 419.

	LEVEL *O*									LEVEL *P*								
	C			*A*			*V*			*C*			*A*			*V*		
	$x -$	–	%	$x -$	–	%	$x -$	–	%	$x -$	–	%	$x -$	–	%	$x -$	–	%
14–17	228	7	3.1	236	58	24.6	256	40	15.6	400	74	18.5	250	131	52.4	324	76	23.5
18–21	151	12	7.9	203	71	35.0	190	20	10.5	227	26	11.5	206	119	57.8	203	26	12.8
22–24	149	12	8.1	182	70	38.5	223	44	19.7	258	43	16.7	190	94	49.5	266	68	25.6
25–29	126	18	14.3	119	23	19.3	167	32	19.2	228	47	20.6	132	66	50.0	228	66	28.9
30–34	146	18	12.3	193	78	40.4	202	75	37.1	295	75	25.4	193	117	60.6	253	109	43.1
35–39	86	19	22.1	81	35	43.2	100	31	31.0	160	46	28.8	92	57	62.0	128	41	32.0
40 or >	118	24	20.3	120	41	34.2	113	36	31.9	206	77	37.4	129	80	62.0	141	45	31.9

TABLE 122 — *Continued*

Individuals of *CAVD* intelligence scores of 420 to 429.

	LEVEL *P*									LEVEL *Q*								
	C			*A*			*V*			*C*			*A*			*V*		
	x −	−	%	*x* −	−	%	*x* −	−	%	*x* −	−	%	*x* −	−	%	*x* −	−	%
14–17	11	0	0	6	0	0	14	0	0	19	2	10.5	13	8	61.5	26	0	0
18–21	86	3	3.5	57	5	8.8	86	8	9.3	133	19	14.3	63	31	49.2	117	15	12.8
22–24	95	1	1.1	72	26	36.1	110	12	10.9	240	5	2.1	85	38	44.7	163	23	14.1
25–29	128	11	8.6	52	21	40.4	129	27	20.9	160	25	15.6	84	52	61.9	158	26	16.5
30–34	100	13	13.0	56	32	57.1	70	17	24.3	113	26	23.0	57	32	56.1	121	44	36.4
35–39	95	12	12.6	34	12	35.3	63	12	19.0	103	18	17.5	63	44	69.8	107	34	31.8
40 or >	112	19	17.0	70	51	72.9	42	11	26.2	135	43	31.8	62	32	51.6	106	24	22.6

TABLE 123

Change with age in the per cent which the number of omissions is of the number of wrong responses and omissions.

Using the Easier Level.

	AGE 14–17			AGE 30–34				AGE 40 OR >			
	x –	–	%	x –	–	%	Change	x –	–	%	Change
Completion											
360–369	312	70	22.4	13	5	38.5	16.1				
370–379	539	80	14.8	11	3	27.3	12.5	12	3	25.0	10.2
380–389	1054	180	17.1	15	6	40.0	22.9				
390–399	225	33	14.7	30	3	10.0	−4.7	5	0	0	−14.7
400–409	358	31	8.7	82	9	11.0	2.3	59	5	8.5	−0.2
410–419	228	7	3.1	146	18	12.3	9.2	118	24	20.3	17.2
420–429	11	0	0	100	13	13.0	13.0	112	19	17.0	17.0
Median (unweighted)							12.5				10.2
Median (weighted)							9.2				10.2
Arithmetic											
360–369	354	110	31.1	14	6	42.9	11.8				
370–379	472	121	25.6	15	10	66.7	41.1	10	4	40.0	14.4
380–389	505	167	33.1	23	16	72.7	39.6				
390–399	287	150	52.3	37	19	51.4	−0.9	13	10	76.9	24.6
400–409	444	136	30.6	102	23	22.5	−8.1	56	10	17.9	−12.7
410–419	236	58	24.6	193	78	40.4	15.8	120	41	34.2	9.6
420–429	6	0	0	56	32	57.1	57.1	70	51	72.9	72.9
Median (unweighted)							15.8				14.4
Median (weighted)							15.8				9.6
Vocabulary											
360–369	365	54	14.8	16	10	62.5	47.7				
370–379	445	69	15.5	4	0	0	−15.5	4	2	50.0	34.5
380–389	774	94	12.1	5	2	40.0	27.9				
390–399	229	27	11.8	14	0	0	−11.8	4	0	0	−11.8
400–409	285	34	11.9	59	16	27.1	15.2	48	12	25.0	13.1
410–419	256	40	15.6	202	75	37.1	21.5	113	36	31.9	16.3
420–429	14	0	0	70	17	24.3	24.3	42	11	26.2	26.2
Median (unweighted)							21.5				16.3
Median (weighted)							21.5				16.3

TABLE 123 — *Continued*

Change with age in the per cent which the number of omissions is of the number of wrong responses and omissions.

Using the Harder Level.

	AGE 14–17			AGE 30–34				AGE 40 OR >			
	x –	–	%	x –	–	%	Change	x –	–	%	Change
Completion											
360–369	565	113	20.0	19	8	42.1	22.1				
370–379	768	170	22.1	14	0	0	– 22.1	9	9	100.0	77.9
380–389	1098	146	14.2	22	8	36.4	22.2				
390–399	90	9	10.0	22	0	0	– 10.0	10	3	30.0	20.0
400–409	509	81	15.9	135	32	23.7	7.8	91	23	25.3	9.4
410–419	400	74	18.5	295	75	25.4	6.9	206	77	37.4	18.9
420–429	19	2	10.5	113	26	23.0	12.5	135	43	31.8	21.3
Median (unweighted)							7.8				20.0
Median (weighted)							7.4				18.9
Arithmetic											
360–369	543	231	42.5	19	6	31.6	– 10.9				
370–379	691	333	48.2	9	0	0	– 48.2	10	10	100.0	51.8
380–389	1397	740	53.0	27	23	85.2	32.2				
390–399	126	81	64.3	15	0	0	– 64.3	12	10	83.3	19.0
400–409	572	285	49.8	137	61	44.5	– 4.3	89	30	33.7	– 16.1
410–419	250	131	52.4	193	117	60.6	8.2	129	80	62.0	9.6
420–429	13	8	61.5	57	32	56.1	– 5.4	62	32	51.6	– 9.9
Median (unweighted)							– 5.4				9.6
Median (weighted)							– 4.3				9.6
Vocabulary											
360–369	507	109	21.5	11	6	54.5	33.0				
370–379	632	99	15.7	2	0	0	– 15.7	4	0	0	– 15.7
380–389	1322	295	22.3	12	4	33.3	11.0				
390–399	74	25	33.8	10	1	10.0	– 23.8	8	3	37.5	3.7
400–409	545	108	19.8	130	36	27.7	7.9	92	34	37.0	17.2
410–419	324	76	23.5	253	109	43.1	19.6	141	45	31.9	8.4
420–429	26	0	0	121	44	36.4	36.4	106	24	22.6	22.6
Median (unweighted)							11.0				8.4
Median (weighted)							19.6				8.4

TABLE 124

Per cents which omissions are of wrongs plus omissions at 14 to 17 and changes from 14–17 to 18–21, from 18–21 to 22–24, from 22–24 to 25–29, etc. The easier and harder levels are represented by I and II.

	IN 360–369		IN 370–379		IN 380–389		IN 390–399		IN 400–409		IN 410–419		IN 420–429		MEDIAN	
	I	II	I	II	I	II	I	II	I	II	I	II	I	II	Unw'd.	W'g'ted
Completions Status at 14–17	22.4	20.0	14.8	22.1	17.1	14.2	14.7	10.0	8.7	15.9	3.1	18.5	0	10.5	14.8	15.9
Change,																
14–17 to 18–21	2.4	17.4	6.3	3.8	.2	1.4	− 10.0	− 6.0	2.1	7.8	4.8	− 7.0	3.5	3.8	2.9	3.5
18–21 to 22–24	47.9	− 4.1	16.4	43.3	29.9	17.7	3.1	11.7	2.5	− 4.1	.2	5.2	− 2.4	− 12.2	4.2	3.1
22–24 to 25–29	− 11.2	4.6	− 29.0	− 36.9	− 14.7	− 5.9	15.1	− 15.7	− .7	9.8	6.2	3.9	7.5	13.5	2.0	3.9
25–29 to 30–34	− 23.0	4.2	18.8	− 32.3	7.5	9.0	− 12.9	0	− 1.6	− 5.7	− 2.0	4.8	4.4	7.4	2.1	4.2
30–34 to 35–39			− 1.1	50.0			.5	0	11.2	16.0	9.8	3.4	− .4	− 5.5	2.0	3.4
35–39 to 40 or >			− 1.2	50.0			− 10.5	30.0	− 13.7	− 14.4	− 1.8	8.6	4.4	14.3	1.6	4.4
Arithmetic Status at 14–17	31.1	42.5	25.6	48.2	33.1	53.0	52.3	64.3	30.6	49.8	24.6	52.4	0	61.5	45.4	45.4
Change,																
14–17 to 18–21	3.9	18.3	2.7	4.0	6.3	9.1	− 12.3	10.7	− 14.8	− 7.1	10.4	5.4	8.8	− 12.3	4.7	4.0
18–21 to	14.4	− 10.8	30.5	30.2	.6	1.4	7.2	− 50.6	− 2.5	− 6.1	3.5	− 8.3	27.3	− 4.5	1.0	.6
22–24 to	− 3.1	22.0	− 10.8	− 4.3	46.1	− 28.6	4.6	− 17.9	15.4	9.0	− 19.2	.5	4.3	17.2	2.4	4.3
25–29 to	− 13.4	− 40.4	18.7	− 78.1	− 13.4	50.3	− .4	− 6.5	− 6.2	− 1.1	21.1	10.6	16.7	− 5.8	− 3.5	− 1.1
30–34 to			− 13.4	50.0			33.2	58.3	− 13.2	− 9.3	2.8	1.4	− 21.8	13.7	2.1	2.8
35–39 to			− 13.3	50.0			− 7.7	25.0	8.6	− 1.5	− 9.0	0	37.6	− 18.2	− .8	− 1.5
Vocabulary Status at 14–17	14.8	21.5	15.5	15.7	12.1	22.3	11.8	33.8	11.9	19.8	15.6	23.5	0	0	15.6	15.6
Change,																
14–17 to 18–21	2.2	8.6	− 2.1	− 3.0	− 2.6	− 5.1	.5	14.2	3.2	.8	− 5.1	− 10.7	9.3	12.8	1.5	− 2.1
18–21	4.3	17.9	36.6	− .2	18.5	17.7	− 1.1	− 34.3	.1	− 3.8	9.2	12.8	1.6	1.3	3.0	1.6
22–24	− 1.7	12.0	− 26.0	12.5	− 12.4	− 10.4	1.8	− 13.7	12.1	17.0	− .5	3.3	10.0	2.4	2.1	2.6
25–29	4.2	− 5.5	− 24.0	− 25.0	24.4	8.8	− 3.1	10.0	− .2	− 6.1	17.9	14.2	3.4	19.9	3.8	10.0
30–34			25.0	0			21.4	13.1	− 5.7	5.6	− 6.1	− 11.1	− 5.3	− 4.6	− 2.3	− 5.3
35–39			25.0	0			− 21.4	14.4	3.6	3.7	.9	− .1	7.2	− 9.2	2.3	.9

BIBLIOGRAPHY OF REFERENCES MADE IN THE TEXT

Bair, J. H. ('02), "The Practice Curve." Monograph Supplement No. 19 to the *Psychological Review.*

Ballard, J. H. ('15), (apparently; the book is undated), *Some Phases of the Psychology of Puzzle Learning.* Printed privately.

Book, W. F. ('08), *The Psychology of Skill: with Special Reference to Its Acquisition in Typewriting.* University of Montana Publications in Psychology: Bulletin No. 53, Psychological Series, No. 1.

Brown, W. ('14), "Habit Interference in Sorting Cards." *University of California Publications in Psychology,* vol. I, pp. 269–321.

Dearborn, W. F., and Brewer, J. M. ('18), "Methods and Results of a Class Experiment in Learning." *Journal of Educational Psychology,* vol. 9, pp. 63–82.

Donovan, M. E., and Thorndike, E. L. ('13), "Improvement in a Practice Experiment under School Conditions." *American Journal of Psychology,* vol. 24, pp. 426–428.

Dorland, W. A. ('08), *The Age of Mental Virility.*

Downey, J. E., and Anderson, John E. ('15), "Automatic Writing." *American Journal of Psychology,* vol. 26, pp. 161–195.

Downey, J. E., and Anderson, John E. ('17), "Retention of Skill after Lapse of Practice: Simultaneous Reading and Writing." *American Journal of Psychology,* vol. 28, pp. 396–408.

Edwards, A. S. ('20), *The Fundamental Principles of Learning and Study.*

Freeman, F. N. ('17), *How Children Learn.*

GONNELLY, J. F. ('17), An unpublished study reported by Freeman in *How Children Learn* ('17, p. 150 f.).

HENDERSON, E. N. ('03), "A Study of Memory for Connected Trains of Thought." *Psychological Review.* Monograph Supplement, No. 23.

HILL, L. B., REJALL, A. E., and THORNDIKE, E. L. ('13), "Practice in the Case of Typewriting." *Pedagogical Seminary,* vol. 20, pp. 516–529.

HOLLINGWORTH, H. L. ('27), *Mental Growth and Decline.*

HOLLINGWORTH, H. L. ('12), "The Influence of Caffein on Mental and Motor Efficiency." *Archives of Psychology,* No. 22.

HOWARD, F. E. ('13), "Psychological Differences between Children and Adults." *Pedagogical Seminary,* vol. 20, pp. 236–253.

JAMES, W. ('93), *Principles of Psychology.*

JONES, HAROLD B. ('27), Data as yet unpublished.

KIRBY, T. J. ('13), *Practice in the Case of School Children.* Teachers College, Columbia University Contributions to Education, No. 58.

KITSON, H. D. ('22), "A Study of the Output of Workers under a Particular Wage Stimulus." *University Journal of Business,* Nov., 1922.

KITSON, H. D. ('25), *The Psychology of Vocational Adjustment.*

LASHLEY, K. S. ('15), "The Acquisition of Skill in Archery." Papers from the department of marine biology of the Carnegie Institution of Washington, vol. 7, pp. 105–128.

LITTLE, PARRISH ('27), A Study of Adult Learning of Shorthand and Typewriting. As yet unpublished.

LYON, D. O. ('16), "The Relation of Quickness of Learning to Retentiveness." *Archives of Psychology,* No. 34.

MEUMANN, E., and EBERT, E ('05), "Ueber einige Grundfragen der Psychologie der Uebungsphänomene im Bereiche des Gedächtnisses." *Archiv für gesamte Psychologie,* vol. 4, pp. 1–232.

MEUMANN, E. ('08), *Oekonomie und Technik des Gedächtnisses.*

MEUMANN, E. ('13), *The Psychology of Learning: An Experimental Investigation of the Economy and Technique of Memory.* Translation by J. W. Baird.

MYERS, GARRY C. ('21), "Prophecy of Learning Progress by Beta." *Journal of Educational Psychology*, vol. 12, pp. 228–231.

NICHOLSON, T. E. ('25), The Increase and Decline in Speed and Control of Voluntary Motor Ability with Advancement in Age. Manuscript from the University of Indiana.

NOBLE, S. G. ('22), "The Acquisition of Skill in the Throwing of Basketball Goals." *School and Society*, vol. 16, pp. 640–644.

PARTRIDGE, G. E. ('00), "Experiments upon the Control of the Reflex Wink." *American Journal of Psychology*, vol. 11, pp. 244–250.

PETERSON, JOHN C. ('20), "The Higher Mental Processes in Learning." *Psychological Monographs*, vol. 28, No. 7, Whole Number 129.

PETERSON, JOSEPH ('17), "Experiments in Ball-tossing: The Significance of Learning Curves." *Journal of Experimental Psychology*, vol. 2, pp. 178–224.

PETERSON, JOSEPH ('18), "Experiments in Rational Learning." *Psychological Review*, vol. 25, pp. 443–467.

PÖHLMANN, A. ('06), *Experimentale Beiträge zur Lehre vom Gedächtniss.*

PYLE, W. H. ('13), "Economical Learning." *Journal of Educational Psychology*, vol. 4, pp. 148–158.

PYLE, W. H. ('14), "Concentrated versus Distributed Practice." *Journal of Educational Psychology*, vol. 5, pp. 247–258.

RADOSSAWLJEWITCH, P. ('07), *Das Behalten und Vergessen bei Kindern und Erwachsenen.*

RUGER, H. A. ('10), *The Psychology of Efficiency.* Archives of Psychology, No. 15.

RUGER, H. A., and STOESSIGER, B. ('27), "On the Growth Curve of Certain Characters in Man" (Males). *Annals of Eugenics*, vol. 2, Parts I and II.

RUGG, H. O. ('16), *The Experimental Determination of Mental Discipline in School Studies.*

SCHULTZE, F. E. O. ('15), "Ueber Lernzeiten bei grösseren Komplexen." *Zeitschrift für Psychologie*, vol. 71, pp. 138–166.

SHAW, J. C. ('96), "A Test of Memory in School Children." *Pedagogical Seminary*, vol. 4, pp. 61–78.

SLEIGHT, W. G. ('11), "Memory and Formal Training." *British Journal of Psychology*, vol. 4, pp. 386–457.

SNODDY, G. S. ('26), "Learning and Stability." *Journal of Applied Psychology*, vol. 10, pp. 1–36.

STONE, CALVIN P. ('27), Unpublished observations of age and learning in the white rat.

SWIFT, E. J. ('03), "Studies in the Psychology and Physiology of Learning." *American Journal of Psychology*, vol. 14, pp. 201–251.

SWIFT, E. J. ('04), "The Acquisition of Skill in Typewriting: A Contribution to the Psychology of Learning." *Psychological Bulletin*, vol. 1, pp. 295–305.

THOMSON, GODFREY H. ('24), "A Formula to Correct for the Effect of Error of Measurement on the Correlation of Initial Values with Gains." *Journal of Experimental Psychology*, vol. 7, pp. 321–324.

THORNDIKE, E. L. ('08), "The Effect of Practice in the Case of a Purely Intellectual Function." *American Journal of Psychology*, vol. 19, pp. 374–384.

THORNDIKE, E. L. ('10), "Practice in the Case of Addition." *American Journal of Psychology*, vol. 21, pp. 483–486.

THORNDIKE, E. L. ('24), "The Influence of the Chance Imperfections of Measures upon the Relation of Initial Score to Gain or Loss." *Journal of Experimental Psychology*, vol. 7, pp. 225–232.

THORNDIKE, E. L., and WOODYARD, E. ('26), "The Relation of Earning Power to Age in Professional Workers under Conditions of Nearly Free Competition." *Journal of the American Statistical Association*, vol. 21, pp. 293–309.

WELLS, F. L. ('08), "Normal Performance in the Tapping Test." *American Journal of Psychology*, vol. 19, pp. 437–483.

WELLS, F. L. ('12), "The Relation of Practice to Individual Differences." *American Journal of Psychology*, vol. 23, pp. 75–88.

WHIPPLE, G. W. ('10), *Manual of Mental and Physical Tests*, p. 247.

WHITLEY, M. T. ('11), "An Empirical Study of Certain Tests for Individual Differences." *Archives of Psychology*, No. 19.

WOOLLEY, HELEN T. ('26), *An Experimental Study of Children.*

YERKES, R. M. ('20), "Psychological Examining in the United States Army." *Memoirs of the National Academy of Sciences*, vol. 15.

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